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PRESSURE LOSSES IN CUSTOMER'S SERVICES[1]

By H. W. Niemeyer[2] and J. A. Bruhn[2]

During the past year more attention has been given the matter of pressure losses in customer's services by the Indianapolis Water Company than in the preceding years. Local progress and developments account for this increased consideration.

With the completion of a city wide meterization program at the end of 1931 the natural tendency is to lend as much assistance as is practical to customers which will create a greater use of our commodity. On the flat rate basis where revenue depended not on the quantity of water consumed, but on other factors, such as number of outlets and types of equipment, it was necessary to place certain restrictions on the usage of the public supply in order to retain peak pumpage loads within reasonable limits and to better control operating costs. It is the policy of our Company through continuous efforts along all possible lines to increase or maintain the consumption of customers and thereby our revenue. We concur with the author who once wrote "Because the growth of any public utility depends largely upon the measure of its success in serving the public, one important index of the Company's achievements in rendering distinguished public service will be the trend of the Company's growth, over and above the natural increase in growth due to the increase of population, and the business development of the territory served;

[1] Presented before the Indiana Section meeting, March 10, 1932.

[2] Indianapolis Water Company, Indianapolis, Ind.

and more particularly the degree to which the Company now is serving its potential market." The customers and the utility will obviously benefit mutually through the greatest possible utilization of the Water Company's service or product. While competition for domestic accounts in Indianapolis is negligible, the efforts of pumping equipment salesmen and other interested parties are a constant threat tending toward the reduction of revenue from industrial and commercial consumers through the installation of private water supplies.

Another factor resulting in closer study being made of service line pressure losses is the attitude of the Indiana Public Service Commission with respect to requiring water companies to maintain and replace existing services where repairs are needed or the delivery is inadequate due to the growth of the consumers demands. Following such tendency on the part of the Public Service Commission and without order from that Commission, we have agreed to do the necessary repair and replacement work on customer's services at our expense. It is interesting to note in this connection that answers to questionnaires sent out to all sections of the country recently by a sub-committee of the committee on Water Works Practice, American Water Works Association, show that in 64 percent of the plants the original service lines from the main to property line are paid for by the customers. Sixty-eight percent of the water companies at the present, repair and replace inadequate services in the street at the expense of the utility. In cities where there is no annual service charge, whether water is used or not, it does not seem logical or just that the Water Company should bear the original cost of services, because the expense including depreciation and maintenance must necessarily be passed on to the other water consumers of the city which results in unfair discrimination. Naturally the closer contact established with inadequate service difficulties throughout the past year has made it advisable to secure all relative information available from outside sources as well as through experiments and field work in Indianapolis.

Sub-normal or inadequate water service, whether caused by factors under control of the water plant or due to conditions within the customer's property, usually always results in complaint against the utility and eventually will tear down good public relations if not properly cared for. Water Works Practice Committee number 9 of the American Water Works Association has deemed the matter of "Service Lines and Consumer's Plumbing" of sufficient importance

to place it on a par with "Pumping Equipment," "Source of Supply Structures," and "Boiler Plant Equipment" in their Public Relations Rating Scale for water utilities. Regrettable though it is, the average user of water without investigating unsatisfactory flow at fixtures and for sprinkling use blames the Water Company. It has been our experience that in many cases inadequate service due to numerous causes such as undersized piping, defective fittings or poor installation, worn or small sprinkling hose, faulty heaters and softeners, or obstruction in the service line has been tolerated for long periods by customers without their complaining to us. Although no inquiry was made concerning the service yet there may have been a question in the users mind, sometimes expressed to others, relative to the efficiency of the utility's service.

CAUSES OF UNSATISFACTORY VOLUME

Causes of unsatisfactory volume of water at outlets which the customer inevitably terms "poor pressure" may be divided into three classifications:

(1) Minimum static pressure in distribution mains.
(2) Service line (size, length, material, obstructions preventing normal flow) meter and connections, necessary valves and cocks are included as part of the service line.
(3) Interior piping.

Our estimate on pressure inquiries received from consumers during the past year show that approximately 60 percent are the result of item number three. The balance practically all come under classification two or a combination of two and three.

During the past five years there has been a marked increase in the demand for water through changed standards of living, new types of plumbing fixtures, lawn sprinkling devices, and cooling equipment. Larger service lines and interior plumbing have not kept pace with the greater demand. This appears to be more or less a natural development and one contributing factor may be that competitive plumbers when figuring on additions to existing systems must keep the cost down in order to increase their possibilities of securing the job. It would of course be a more satisfactory and permanent policy for the owner to have competent specifications made on the work.

HANDLING OF INQUIRIES

Beginning several years ago all inquiries coming to the Indianapolis Water Company, whether by letter, telephone, or directly from

consumers were centralized in a division of the Commercial Department. On those requiring an investigation monthly records are kept and letters written informing the customers regarding the matter. The monthly report on inquiries received bears the following information classified in groups according to the nature of the inquiry—name, address, explanation or cause, date of disposition, and a summary on the total number of inquiries.

General inquiries may originate in any of several departments and are sent in triplicate to the Inquiry Division which distributes them to the proper investigating department, one of the copies being kept as a check to make sure the matter is properly consummated. From the investigating department a report goes back to the Inquiry Division which, providing the information seems satisfactory, informs the inquirer by letter. The department doing the investigating keeps a record of the case for future reference. The present inquiry system seems to work smoothly and we receive many favorable comments from customers regarding the service given along such lines.

The usual procedure on pressure or volume inquiries is for the Inquiry Division to refer the matter to the Service Department which first sends out the District Man who covers that section of the city. Many times this man can locate the cause of the trouble when it is due to faulty heaters, furnace coils, softeners, partly closed valves, stuck meters, and so on. However, should his report not seem conclusive or satisfactory to the Superintendent of Service and the Inquiry Division two other men investigate the case with pressure gauges and a test meter. The test meter carries gauges on the inlet and outlet sides which facilitate the work. These men by observing the gauges on the meter and one on the highest fixture make a report of drops in pressure for various size flows. A stop watch is used to clock the various registrations on the test meter. By opening first one outlet and then additional ones the location and extent of the trouble can be found. These data along with additional information as to size of corporation cock, length and size of service line and interior piping, and static main pressure are turned over to the Superintendent of Service, who can easily determine whether or not the pressure loss in the service line and interior piping is more than normal. The Inquiry Division then studies the monthly consumption of that particular customer, nature of their business, and probable peak requirements, after which recommendations are made as to disposition of the case.

CAUSES OF LOW PRESSURE

For the year 1931 experience indicated that on about 60 percent of the pressure inquiries the cause was due to matters under the control of the customer such as inadequate main line piping in the property, defective water heaters, furnace coils, softeners, valves, and fixtures. Approximately 25 percent resulted from some obstruction in the corporation cock, curb cock, service line, meter yoke, or meter. The balance proved to be a combination of inadequate service line and small inside piping. Under our present policy recommendations are made to the responsible parties as to the cause of the trouble and steps recommended for its elimination. We have found that in cases where both the service line and inside piping are inadequate it is wise to have the customer make his changes *before* the service is enlarged in the street—otherwise the inside work may never be done. A good test of whether the customer is inconvenienced by his lack of volume is his willingness to make some expenditure on larger inside piping in order to better the situation. On a few cases consumers have been unreasonable in their requests that the Water Company replace their services. If the Company installed these at the whims of individuals without first making careful investigation, capital investments would be rapidly and unnecessarily increased.

In Indianapolis a minimum pressure of 55 pounds is carried in the central section of the city and with the exception of the Eastern District where a 1½ million gallon elevated storage tank assists in maintaining good pressure, the elevations are such that normal pressure is greater than in most cities of the United States. Therefore, troubles due to poor distribution pressure are not present.

Due to the chemical nature of the water supply, the character of the soil, and the fact that lead services seem to work satisfactorily in Indianapolis, we do not experience serious service line difficulties. In a few cases where examinations were made in our laboratories of parts of old lead services removed we find deposits which the Filtration Department attributes to weak electrolytic action due not to external causes, but normal physico-chemical phenomena. The number of these is not extensive and in general we are fortunate with respect to service trouble caused by corrosion, tuberculation, or nodulation.

In Indianapolis the greatest cause of poor pressure difficulties is

lack of intelligent foresight on the part of plumber, builder, architect, or property owner. The tendency is toward too liberal use of "rule of thumb" methods for calculations and failure to recognize the fact that demands for water have increased. Investigations constantly reveal "overloaded" inside piping systems. The adoption of "a factor of safety" on new installations would allow for future additions to systems and should eliminate many troubles now experienced. Some customers through false economy in expenditures on questionable size water pipe make satisfactory service practically impossible. The greater use by owners, plumbers, and architects of the available experience of water works men should help materially in decreasing the number of inquiries on poor service.

During our studies of pressure losses in customer's services, requests were sent to the following water companies in the country to learn their precedure in investigating such cases: Pennsylvania Water Company, San Francisco, Hartford, Milwaukee, Detroit, Hackensack, Scranton—Spring Brook, and New Haven. Their policies are essentially the same as described for Indianapolis—the amount of attention and study given the matter being determined by:

(1) Local water supply and soil conditions.
(2) State rulings as to responsibility for services.
(3) Type management.
(4) Desire to increase good public relations and revenue.

The discussion up to this point has been confined chiefly to the relation of the subject to general local conditions and factors. Now some thought should be extended to the technical side of the subject.

GOOD SERVICE

What constitutes good service? The answer is somewhat a matter of opinion, but it is generally recognized that a minimum static pressure of 15 pounds per square inch is required at each fixture when no water is flowing at that fixture. This means that the service line and the house plumbing must be so designed that a static pressure of 15 pounds per square inch remains at the highest fixture when the average probable number of other fixtures are in operation. Therefore, the proper design of supply pipes is dependent on ability to forecast the probable demand of all fixtures and knowing the capacity of a combination of service line materials.

There is ample information available in textbooks concerning the

rates of flow required by all types of fixtures, but no simplified method of determining the maximum and probable demand of a group of fixtures has been set up. The coincidence of demand of a group of fixtures will vary in different classes of service. It is quite evident that a lavatory in a public rest room will have a more frequent and different duration of demand than one located in a private residence. Reference to proposed studies of this phase of the subject will be made later.

LOSS OF HEAD IN SERVICES

A wealth of information is available concerning capacities of various service line material including a paper by James E. Gibson published in the June 19, 1929 issue of Water Works Engineering, and texts on hydraulic characteristics of small straight pipes. However, detailed information was still lacking that could be applied to local installations, so that it was necessary to conduct a series of pressure loss tests of service line materials, which included corporation cocks, copper, lead, and wrought iron pipe, curb cocks, meters, meter yokes, stop and waste valves, and reamed and unreamed pipe cuts, all in sizes up to one inch. No attempt was made to study the larger size service lines inasmuch as their hydraulic characteristics are available in hand-books. May we say that in so far as the tests are similar, the results obtained agree within a small percent with those obtained by Mr. James E. Gibson.

Briefly, the tests were conducted by determining the losses of head with mercury manometers which were connected by small tubes through small orifice openings on either side of the various material to be tested. All materials listed are approved by the Indianapolis Water Company and were set up for test to duplicate types of installations in actual service. Pressure losses for all material have been recorded for six different rates of flow. Each test was run for ten minutes and manometers observed at one minute intervals. At the conclusion of the ten minute run, the amount of water discharged was weighed and divided by ten to give the rate of flow per minute. The pressure drop readings were averaged for the ten minute periods. It was decided to test odd lengths of pipe in order to conform as near as possible to actual installations but results were interpreted for lengths of one hundred feet. All results are plotted on true logarithm paper.

It must be remembered that results obtained indicate flows for

new materials and consequently are in variation with any that would be obtained after materials had been in service for periods of time. The progressive changes in the hydraulic characteristics of pipes with service have been thoroughly tested and reported by G. M. Fair, M. C. Whipple, and C. Y. Hsiao of Harvard University, as published by the Journal of the New England Water Works Association (Vol. XLIV, No. 4) under the title of "Hydraulic Service Characteristics of Small Metallic Pipes." The diminishing capacity of steel and wrought iron with age as compared to copper tubing is clearly demonstrated. For this reason it is considered advisable to recommend the use of larger size wrought iron pipe than in the case of copper tubing. The present cost of copper and its characteristics are such as to warrant earnest consideration for its uses from main to fixture. Stream line fittings for copper tubing were not on the market at the time of the tests, but we feel certain that some interesting and favorable data as to pressure loss would have been derived had flows in such fittings been obtained.

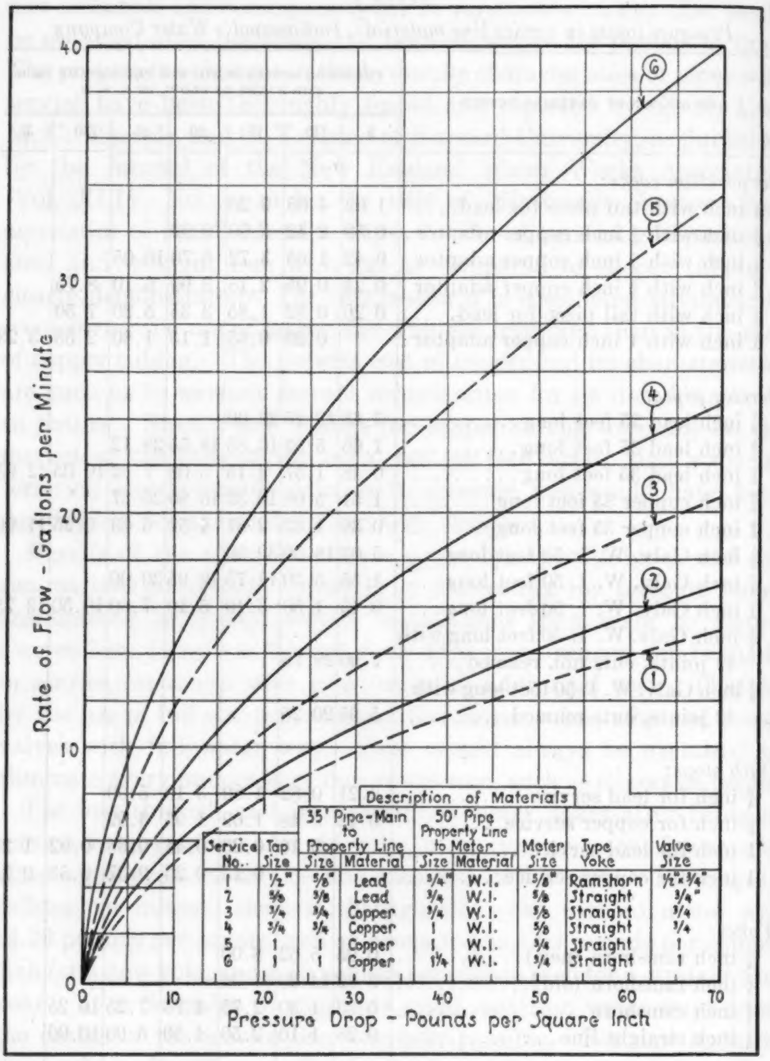
Results of the observations are given briefly in table 1 and are summarized graphically (figure 1) by illustrating the pressure losses encountered in typical service installations from main to meter. Curves Nos. 1 and 2 in figure 1 show what improvement can be made in service capacities with practically no additional cost. That is, by the use of full size tap, straight line meter yokes, stop and waste valves with full water way. Care should always be exercised to eliminate every unnecessary flow restriction, such as elbows or bends.

The loss through cast iron ramshorn meter yokes after being in service, is surprising. An old yoke in an average state of corrosion after some years of service was included in the tests. Flowing 10 gallons per minute, the loss through this yoke without meter was 14.20 pounds per square inch as compared to 3.62 pounds per square inch for a new yoke and 1.30 pounds per square inch for a straight line yoke. It is desirable to eliminate small cast iron water ways from the design of the service line wherever possible. For new installations where direction of plumbing is convenient, the straight line yoke, which sets in a horizontal run of pipe is most satisfactory. For replacement of the cast iron yoke located in a vertical riser, a yoke with an all copper water way is on the market. In discussing the question of yokes, we call attention to the selection of gaskets. It has been found that rubber gaskets mash out with service and often decrease the orifice in the waterway to an opening as small as $\frac{1}{4}$ inch.

TABLE 1

Pressure losses in service line materials, Indianapolis Water Company

DESCRIPTION OF MATERIAL TESTED	PRESSURE LOSSES IN POUNDS PER SQUARE INCH FOR RATES OF FLOW, IN G. P. M.						
	5	10	15	20	25	30	35
Corporation cocks:							
½ inch with tail piece for lead	1.02	4.05	9.25				
½ inch with ¾ inch copper adaptor	0.59	2.42	5.60	10.02			
⅝ inch with ¾ inch copper adaptor	0.42	1.65	3.72	6.70	10.05		
¾ inch with ¾ inch copper adaptor	0.24	0.95	2.15	3.90	6.10	8.75	
¾ inch with tail piece for lead	0.20	0.82	1.85	3.35	5.20	7.50	
1 inch with 1 inch copper adaptor		0.29	0.65	1.15	1.80	2.55	3.23
Service pipes:							
⅝ inch lead 35 feet long	3.68	12.25	28.00				
¾ inch lead 35 feet long	1.66	5.53	10.85	18.55	28.12		
1 inch lead 35 feet long	0.48	1.57	3.15	5.08	7.52	10.05	12.95
¾ inch copper 35 feet long	1.51	5.08	10.32	16.80	26.37		
1 inch copper 35 feet long	0.39	1.32	2.81	4.52	6.69	9.25	11.90
½ inch Galv. W. I. 50 feet long	5.03	18.50	39.50				
¾ inch Galv. W. I. 50 feet long	1.55	5.50	11.75	19.95	30.00		
1 inch Galv. W. I. 50 feet long	0.45	1.50	3.10	5.10	7.60	10.50	13.75
½ inch Galv. W. I. 50 feet long with 12 joints, cuts not reamed	7.90	28.75					
½ inch Galv. W. I. 50 feet long with 12 joints, cuts reamed	5.95	20.25					
Curb stops:							
¾ inch for lead service	0.21	0.82	1.80	3.10	5.00		
¾ inch for copper service	0.12	0.48	1.09	1.95	3.02		
1 inch for lead service		0.10	0.23	0.41	0.65	0.92	1.25
1 inch for copper service			0.13	0.23	0.37	0.53	0.75
Yokes:							
⅝ inch ramshorn (new)	0.95	5.62	8.00				
⅝ inch ramshorn (old)	3.62	14.20	31.00				
¾ inch ramshorn	0.33	1.30	2.75	4.75	7.25	10.25	
⅝ inch straight line	0.28	1.10	2.50	4.50	6.90	10.00	
Stop and waste valves:							
½ inch by ¾ inch compression valve	1.70	6.75	15.00				
⅝ inch by ¾ inch compression valve	0.87	3.15	7.00				
¾ inch by ¾ inch compression valve	0.51	2.05	4.55	8.00			
1 inch by 1 inch compression valve	0.31	1.31	2.95	5.30	8.25	11.50	16.0



Service No.	Tap Size	35' Pipe-Main to Property Line Size	35' Pipe-Main to Property Line Material	50' Pipe Property Line to Meter Size	50' Pipe Property Line to Meter Material	Meter Size	Type Yoke	Valve Size
1	1/2"	5/8"	Lead	3/4"	W.I.	5/8"	Ramshorn	1/2"×3/4"
2	5/8	5/8	Lead	3/4	W.I.	5/8	Straight	3/4"
3	3/4	3/4	Copper	3/4	W.I.	5/8	Straight	3/4
4	3/4	3/4	Copper	1	W.I.	5/8	Straight	3/4
5	1	1	Copper	1	W.I.	3/4	Straight	1
6	1	1	Copper	1 1/4	W.I.	3/4	Straight	1

FIG. 1. INDIANAPOLIS WATER COMPANY. PRESSURE LOSSES IN CUSTOMERS' SERVICES BETWEEN MAIN AND METER, MARCH, 1932

A composition washer is now being used with more success by the Indianapolis Water Company.

We dare say that only few manufacturers of stop and waste valves

have given careful consideration to pressure loss when designing their valve. They have apparently paid most attention to design as related to cost of production. For instance, there are quite a few $\frac{3}{4}$ inch valves on the market which have only $\frac{1}{2}$ or $\frac{5}{8}$ inch waterways. Flowing 10 gallon per minute through $\frac{1}{2}$ inch by $\frac{3}{4}$ inch, $\frac{5}{8}$ inch by $\frac{3}{4}$ inch, and a full $\frac{3}{4}$ inch valve, pressure losses of 6.75, 3.15, and 2.05 pounds per square inch respectively were recorded. It is well for the utility operator to restrict the use of valves to those of approved design whenever possible.

Every well prepared plumbing specification calls for the reaming of all pipes to insure that they will deliver their full capacity. Results bear out the need of that specification. When flowing 10 gallons per minute through 50 feet of $\frac{1}{2}$ inch galvanized wrought iron pipe with 12 joints cut in that length the pressure loss was reduced from 28.75 to 20.25 pounds per square inch, by reaming the cuts. Also the incrustation of increased joints cuts down the area of the pipe at that point materially in a short time. The builder is liable to and often does lose sight of the importance of this item in accepting the lowest bid for the plumbing work. Control of installation of house plumbing is beyond the jurisdiction of the utility operator and he can only emphasize its importance to all parties concerned.

The selection of meters also has a bearing on this subject, but we will limit the discussion to the comment that we feel there is a decided tendency to oversize the meter. Sight should not be lost of the importance of accurate registration.

It is the practice in Indianapolis to install the service line between main and property line in advance of permanent street improvements. In order to guarantee satisfactory service to the future customer it is desirable to forecast the type of dwellings that will be built in districts. That is, it is necessary to zone the city and install services of sizes in keeping with the estimates on types of future development. As every utility has a different problem, no definite recommendations are considered necessary. Curves 1 to 6 on figure 1 are given to show relative capacities of typical services. Allowing a twenty pound per square inch pressure drop between main and meter, good service may be obtained for maximum flows of 7.8 gallons per minute for service No. 1, 8.7 for No. 2, 10.7 for No. 3, 12.8 for No. 4, 17 for No. 5, and 20.9 for No. 6. The above designs are typical and must be varied to suit local conditions such as distribution pressure, length of service, and other factors.

In order to acquaint its customers with causes for unsatisfactory service the Indianapolis Water Company has recently prepared a small educational leaflet. This will be distributed to architects, builders, plumbers, persons inquiring about pressure troubles, and those building new homes. It is hoped that through this and other avenues we may help customers benefit by studies that have been made.

Studies completed to date are only the beginning on the securing of desired information relative to the subject. It has been recently learned that the Neptune Meter Company is considering the manufacture of a recording register for water meters. We feel that such a device is an important and needed step in the future development of these studies. Such a register installed with a meter in various types of services will tell a graphic story of their demands, and it is hoped that with a collection of such data a practical ratio between demand and number of fixtures can be determined. The instrument would also prove advantageous in cases where the customer encounters poor pressure during certain peak consumption hours or at other random periods. Indications are that the register will be on the market soon and it should be of much help to plant operators.

Not only from the angles of satisfactory service to consumers, responsibility or obligation, and increasing revenue is it deemed advisable that water companies make strong efforts to supply the growing demands for water through elimination of avoidable pressure losses in supply lines, but also because the only other solution to the matter is the maintaining of greater pressure in the general distribution system resulting in higher operating costs which the well managed organization is endeavoring to reduce.

TASTE AND ODOR ELIMINATION[1]

By John R. Baylis[2]

A very serious problem confronting a number of water works throughout the country is the elimination of objectionable tastes and odors. In most instances taste only will be mentioned in the article, but it is intended to include both tastes and odors. Progress has been so rapid in the perfection of methods for preventing or removing tastes that almost any water works may now, by some one of the methods, completely eliminate objectionable tastes. The most economical method will depend somewhat upon the compound or compounds responsible for the taste and upon local conditions. In one water it may be the ammonia-chlorine treatment, in another activated carbon, and in others superchlorination, aeration, potassium permanganate, or ozone, may be best suited for producing perfectly palatable water. Probably in a few instances it will require the combination of two or more of the treatments for eliminating the objectionable tastes.

So much has been said recently about the relative merits of the various treatments that many of the filter plant and water works operators are becoming confused, for we find conflicting opinions throughout the published articles on this subject. One operator will report a certain taste, and then state that it was removed or prevented by a certain treatment. Another operator will report a similar taste, but finds the treatment does not remove it, or only partially removes it. In many such instances the tastes may actually be different or produced from different compounds. In the development of new processes, and especially processes for the removal of taste from water, it is expected that there will be many complications. The problem is still more complicated because in so many instances we know very little about the compounds responsible for the taste. We refer to the water as having an algae taste, a musty taste, or a fishy taste, yet we do not have the slightest idea of the nature of the compound that produces the taste.

[1] Presented before the Minnesota Section Meeting, October 30, 1931.

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Combined with a lack of knowledge of the compound producing the taste, there is no accurate means of determining when the water is free from taste, or of determining the intensity of the taste. Standard Methods of Water Analysis (1) gives a somewhat vague method of expressing the quality and the intensity of odors, but it does not meet the needs for a more specific determination. Four or five workers who have had much experience in the testing of taste in water will vary widely on their classification of the kind and the intensity of the taste in a certain sample of water. This makes us regard records of taste tests with considerable uncertainty.

QUALITIES OF TASTES

The quality of the taste likely to be present in a water supply varies widely. In the absence of specific knowledge of the compound or compounds producing the taste, in most instances, it is customary to distinguish the taste with the taste of some object of which we are familiar. The following tastes have been referred to in the literature and serve as a means of classifying the tastes:

Aldehol	Limy
*Algae	Medicinal
*Aromatic	*Marshy
Burnt leather	*Moldy
Chlorine	*Musty
Chlorophenol	*Melting ice
Creosote	Oily
*Decaying vegetation	*Pig pen
*Decomposition	*Peaty
Disagreeable	*Ripe cucumber
*Earthy	*Rivery
*Fishy	Sewage
Flat	*Stagnant
Gaseous	*Swampy
Gasoline	Sweetish
*Grassy	Tarry
*Humic acid	*Woody
*Hydrogen sulfide	

* Refers to tastes largely of natural origin.

As to the number of compounds that go to make up the various tastes which have been defined, we do not have any idea. Perhaps hundreds of compounds are responsible. It is usually customary to

report the intensity of the taste in accordance with the method given in Standard Methods of Water Analysis for reporting odors.

0	None
1	Very faint
2	Faint
3	Distinct
4	Decided
5	Very strong

The method of defining the intensity of the taste is about as unsatisfactory as the classification for the quality of the taste. It is better than nothing, yet there is not much more that may be said in its favor. If some one could perfect a more positive method of defining the quality and intensity of tastes in water, it would be a distinct service to the profession.

Tastes of natural origin

The list of tastes show that over one-half of them are of natural origin; that is, they are not usually caused by pollution of the water with waste products from industries, etc. The most prevalent tastes of natural origin are produced by microscopical growths in the water. This includes the algae, aromatic, fishy, grassy, pig pen, ripe cucumber and several others. Most of the tastes resulting from microorganisms probably are classified as algae or fishy. One thing that makes the tastes produced from microörganisms more likely to occur than some of the other tastes is that microörganisms grow abundantly in any clear pure water suitable for a water supply. Practically all that is necessary is sunlight and carbon dioxide.

Industries disposing waste products that may cause taste in water

A variety of industries, as shown by the following list, have waste products that might cause disagreeable tastes should the waste happen to get into the water used for a public supply.

By-product, coke-oven plants
Gas plants
Canneries
Textile mills
Oil refineries
Paper mills
Milk product plants
Beet sugar mills

Glue factories
Meat packing houses
Steel mills
Tanneries
Dye manufacturing plants
Creosoting plants
Alcohol manufacturing plants

The above list and probably several other types of industries have been known to discharge wastes that produce taste in water. Most industries have certain waste products that must be disposed of in some manner, and sometimes it is possible for the industry to exist only where its waste products can be disposed of cheaply. The industries should be required to coöperate in preventing objectionable compounds getting into water used for a public supply, but it is impossible to eliminate completely all industrial pollution of objectionable character. Water supplies located where pollution is possible should make provisions for the prevention or the removal of taste-producing compounds, should such compounds happen to get into the water; that is, dependence should not be placed solely upon the industries to prevent tastes from getting into the water, even though they are supposed not to discharge objectionable waste products. With good supervision they sometimes have mishaps that allow the streams to become polluted.

Manufacturing industries give employment to the people and make it possible to build great industrial centers. Therefore, the inhabitants of the great industrial areas should not place such a burden upon the industries for the disposal of their waste products as to cause them to move elsewhere unless it is necessary. The problem should be one of coöperation between the inhabitants and the industries. Sometimes certain types of industries should be required to move. Water works officials should be alert to developments in the treatment of polluted water and be ready to meet increased pollution should it come as a result of increase in industries and in population.

PROGRESS IN TASTE ELIMINATION

Rapid progress has been made within the past five years in the development of methods for preventing or removing objectionable tastes from water. At the present time we are on the verge of saying there is no excuse for any water works delivering water to the consumers containing objectionable tastes. Some very likely will not

agree with this statement, yet in nearly every city where real efforts have been made to remove tastes, great improvement has been made. The filter plant operators by trying first one and then another taste prevention usually find some treatment to handle most any condition of the water. Certainly we have reached the stage where most wide awake operators feel that they should make some effort to eliminate the taste. In fact, we might say the public is reaching the stage where they will no longer tolerate disagreeable tastes in their drinking water. Where operators do not feel inclined to make efforts to reduce objectionable tastes, they are going to meet with such criticism from the public that they will be forced to do something or to get out and let someone else take charge. The best advice that can be given to filtration plant operators where the water has objectionable taste is to get busy and remove the taste. If you need expert advice the citizens will in nearly all instances be willing to make a reasonable expenditure for such advice.

METHODS OF PREVENTING OR REMOVING OBJECTIONABLE TASTES

For many years the operators of water plants struggled along trying to reduce taste by one or two methods—filtration and aeration. In most instances both processes were used. A great deal may be accomplished by filtration of water in the elimination of some types of taste, and tastes or odors that are produced by dissolved gaseous compounds may be greatly reduced by aeration. It is not the purpose of this article to discuss what is accomplished by filtration. It is assumed that the water has been properly treated to make it clear and bacterially safe. If, by increasing the chemicals other than chlorine used in the treatment, the amount of chlorine necessary to make the water safe bacterially is reduced, a plant is justified in so doing. Not much will be said about aeration, for its value is now fairly well understood. It is effective for certain types of tastes, yet almost every one knows that it is not the solution of the taste trouble for most waters. Aeration has its place in water treatment, and what it will do in removing tastes is fairly well known. Those who have the hope that it will be all the treatment that is necessary are going to be disappointed in many instances. Where it proves effective, it is a very simple process and if it is the most economical treatment that really eliminates the tastes it is the treatment that should be used.

The ammonia-chlorine treatment

The most widely used treatment for the prevention of objectionable tastes in water at the present time is what is known as the ammonia-chlorine treatment. Ammonia, or some ammonium salt such as ammonium sulfate, is added to the water in advance of the chlorine. The chlorine unites with the ammonia to form chloramine instead of forming objectionable chlorinous tastes. The use of ammonia is not for removing tastes already in the water, but for preventing chlorinous tastes or tastes made more pronounced by the addition of chlorine to the water. It is necessary to add chlorine to the taste-producing point to make many waters pass the bacterial standard for drinking water, and where this is the case ammonia can, in most instances, be used to prevent the taste. It is necessary to have a longer contact time to kill bacteria when ammonia is used, but when the time is over two hours excellent disinfection may be obtained.

Chlorine is regarded as a strong oxidizing agent and chloramine is probably a weak oxidizing agent. Where the water contains considerable oxidizable organic matter a saving in the cost of disinfecting the water may be effected by the use of chloramine, for so much of the chlorine is not used up in oxidizing harmless organic compounds. The residual chlorine remains in the water very much longer and gives added safety to the water where there is the possibility of contamination beyond the point where the chlorine is added. It is not the purpose of this paper to discuss the bactericidal efficiency of chloramine, for this has already been covered very thoroughly by Gerstein (2) and others. It seems probably that almost any desired amount of residual chlorine may be carried in the water without producing chlorinous tastes when the proper amount of ammonia has been used. A residual chlorine of 0.5 p.p.m. usually cannot be detected when it occurs in the water in the form of chloramine, and where there is a time of several hours after the addition of the chlorine before the water reaches the consumers, this is long enough to make the most highly polluted water sterile.

Ammonia is very effective in preventing chlorophenol tastes when phenol or any of the phenolic compounds are present in the water. Using ammonia still waste liquor from a by-product coke-oven plant, the writer has been successful in preventing most of the objectionable tastes produced by the addition of chlorine, although in some instances there was a noticeable taste. If the taste is not prevented

entirely, it is prevented to the extent that fairly small quantities of phenol will not produce a very objectionable taste.

Several writers have reported tastes other than the chlorinous tastes, or tastes made more pronounced by the addition of chlorine, being eliminated by the ammonia-chlorine treatment. In some of the experiments conducted in our laboratory the taste has been shown to be reduced by the treatment. Taste tests are so unreliable in judging the efficiency of a treatment that it is difficult to state at the present time whether tastes other than those produced as a result of the addition of chlorine to water are actually reduced. The evidence seems to be more in favor of saying that some of the other tastes are reduced, at least slightly. It may be that certain easily changed compounds can be attacked or broken down with a high residual chlorine that is usually maintained with the use of ammonia, the ammonia perhaps playing no part in changing the offensive compound except to allow a high residual chlorine to be maintained without it producing a taste. This statement is made with practically no evidence to support it, yet such reactions seem possible. We know that prechlorinating to the extent that the residual chlorine is about the same as that usually carried when ammonia is used is beneficial in reducing certain tastes. A great deal probably depends upon the compound, and it may be that only a few compounds are capable of being changed under such conditions. It is probable that some have given ammonia credit for the reduction of certain tastes, where as a matter of fact the taste was reduced by other means such as filtration. The elimination of chlorinous tastes and tastes made more pronounced by the addition of chlorine certainly justifies the use of the ammonia-chlorine treatment in many waters.

Activated carbon

Recently there has come into use a material for removing objectionable tastes from water known as activated carbon. It gets its name for the fact that it has been treated in a special manner to make the surface atoms of the carbon highly adsorptive. Active carbon can be made from many carbonaceous materials. It is usually prepared by low temperature carbonization of carbonaceous material to form what is known as the primary carbon, then the primary carbon is activated by heating to a high temperature and passing steam or a small amount of air through the material in closed retorts. Considerable care is required in the preparation of an active carbon, and

for this reason it will never be as cheap as charcoal. A highly active carbon has from 25 to 100 times the adsorptive capacity of ordinary charcoal.

Many organic compounds are adsorbed by active carbon. In fact Michaelis (3) states that there are only two substances known hitherto which are not adsorbed by charcoal—the sulfates of alkaline metals and glycocoll. There is no taste-producing compound likely to be present in a water supply that cannot be adsorbed by carbon. It may not be economical to try to remove some of the compounds by carbon, yet it can be done at some price. We are finding that many, if not all, the taste-producing compounds which have given trouble in public water supplies can be removed by carbon at an expenditure which a water works can afford to make. The amount of substance a unit weight of activated carbon will remove from water varies widely for different compounds, and the amount of the compound required to produce taste in water also varies widely. When a fairly large amount of some substance is present in water the adsorptive capacity of the carbon may be reduced so rapidly it is not economical to remove the compound with carbon. We can expect a highly active carbon to adsorb approximately 0.5 percent of its weight of phenol, and phenol is much more readily adsorbed than many of the compounds.

Our lack of knowledge of the compounds producing much of the taste in water makes it difficult to predict in advance the load that will be thrown upon the carbon. Some of the tastes produced by microorganisms, commonly called algae tastes, are readily removed by active carbon. The only conclusion we can reach is that such compounds are adsorbed very highly, or the taste is produced by extremely minute quantities of the compounds. Sometimes tastes thought to come from microörganisms are not so readily adsorbed by an active carbon. Most of what is known about the effectiveness of activated carbon in removing objectionable tastes is from places where the material has been tried. If we know the chemical compound or compounds responsible, it would be possible by examination to form some idea of what to expect. Presumably the only way fairly accurate data on the effectiveness of active carbon may be obtained for a given water or a certain taste is by actual trial on the water.

The fact that the carbon adsorbs so many compounds likely to be present in water, its capacity may be greatly reduced for the adsorption of offensive compounds. Kolthoff (4) shows that when two

compounds, both of which are readily adsorbed by carbon, are in solution such as phenol and resorcinol, neither compound will be adsorbed to the extent it is adsorbed when alone in the solution. In other words, when the carbon has adsorbed a quantity of some certain material, this cuts down on its adsorptive capacity for some other material. Some compounds probably have the power of replacing other compounds, and it may be that a compound strongly adsorbed will replace a weakly adsorbed compound and be adsorbed almost to its fullest extent regardless of the presence of the other compound. Then, if the taste-producing compound is one which is strongly adsorbed, it may be removed from the water even though the carbon has already saturated itself with other compounds and would not remove weakly adsorbed compounds.

Adsorptive capacity should not be confused with the strength with which the adsorbed compounds are held on the surface of the carbon. Naturally we know very little about the binding strength of carbon and the adsorbed compounds. One person may report a mouldy odor in the water that is readily removed by active carbon. Another may report the same odor and state that a large amount of powdered carbon is required to remove it. The chemical compounds producing the mouldy odor may differ widely in the two cases, and also it may require a very much larger amount of one compound to produce a certain intensity of odor than the other. These facts are mentioned not to discourage the use of carbon, either in the powdered or the granular form, but to explain why different water works will obtain results that appear to vary widely. There will be many things about the action of activated carbon that will be difficult to explain until we have used such materials for considerable time.

The use of powdered activated carbon is being extended quite rapidly into the water works field as a means of removing objectionable tastes from water. The writer has no record of the number of cities that use powdered activated carbon at the present time, but the number is believed to exceed 50. In fact it has been tried in many more plants where the taste occurs only occasionally. Bay City, Michigan (17) is the largest city using beds of the granular carbon. Dundee, Michigan (5) also has a bed of activated carbon for passing the water through before it goes to the consumers. Goudey (6) is experimenting with its use in handling a very highly polluted water. Activated carbon seems to be attracting considerable attention in Europe as well as in America. Liddle (7) describes the activated

carbon filter at Hamm, Germany and predicts a very bright future for activated carbon. It was found necessary to reactivate the carbon after one and one-quarter years. The rate of flow through the bed was very much higher than that customarily used for rapid sand filters.

The writer has not found it necessary to reactivate a bed of active carbon 24 inches in depth after nearly three years continuous service at a rate of 2 gallons per square foot per minute. Early experiences with this bed have been described (8). It is believed that many make the mistake of using too high velocities through the beds. This may save in first cost, but it is believed that maximum economy will be obtained when the rate is not very high. The customary rate for rapid sand filters is a very good rate to use for beds 24 inches in depth; that is, 2 gallons per square foot per minute. Greater rates may be used for deeper beds. The writer (9) found that a bed 48 inches in depth will dechlorinate water as effectively at 6 gallons per square foot per minute as a bed 24 inches in depth at a 2 gallon rate. This may not apply for taste-producing compounds, as the removal of tastes is a direct adsorption and the removal of free chlorine appears to be a reaction of the oxygen of the hypochlorous acid with the carbon to form carbon dioxide.

Superchlorination

Chlorine, before the use of ammonia, was responsible for more taste in water than any other substance, yet superchlorination is a destroyer of tastes. The water, of course, has to be dechlorinated before delivery to the consumers. Superchlorination may have become a fairly extensive taste prevention treatment if other methods of taste removal had not been developed. It is being used at Toronto (10) very successfully, and Hale (23) reports that it was successful in removing medicinal tastes from the well water at Jamaica Bay, N. Y. Houston (11), in 1920, pointed out the possibility of removing certain tastes by the use of an excess of chlorine. The addition of an excess of chlorine to destroy the "ripe cucumber" taste in the Catskill water of the New York Water Supply was used in January, 1922 (12).

The amount of chlorine necessary to add to the water to destroy tastes varies widely. It is desired to have a residual of about 0.5 p.p.m. or higher several hours after application of the chlorine, and this may require from 1.0 to 5.0 p.p.m., or even more to produce this residual. A few workers have reported a very high superchlorina-

tion producing disagreeable tastes in the water even though the treatment destroyed the taste for which it was added. This seems to be the trouble in a few instances when water with high residual is thrown on to filter beds containing considerable organic matter. Very likely with continued use of highly chlorinated water such tastes would soon cease. This is not saying that superchlorination will not produce certain tastes when the chlorine reacts with certain compounds in the water, even though the water is later dechlorinated. It is not believed, however, that compounds which produce tastes under such conditions are likely to be present in many water supplies. Superchlorination is a method of destroying many of the taste-producing compounds likely to be present in potable water.

Dechlorination

The success of the superchlorination treatment depends to a large extent upon the effectiveness of the dechlorination treatment. Insufficient dechlorination once or twice a week is enough to overbalance the good done by superchlorination. The dechlorinating compound must be added continuously in the amount needed, if the dechlorination is done by the addition of some compound to the water. Toronto uses sulfur dioxide. Hale used sulfur dioxide at Jamaica Bay. Glencoe and Winnetka, Illinois, have been using sodium bisulfite. Ordinary lignite is very effective in dechlorinating water, if it is passed through beds of the granular material. The Candy Filter Company patented the use of raw lignite for dechlorination in 1915 (13). Ordinary wood has some dechlorinating properties, so does anthracite coal. The most effective dechlorinating agent of this kind is activated carbon. The activated carbon is not only a dechlorinating agent, but, as has been explained, is a method for removing the objectionable tastes.

The chlorine-activated carbon treatment

A treatment where the water is superchlorinated and then dechlorinated by activated carbon is believed to be the most effective process that may be used. The carbon used in such treatments is beds of the granular material. It is not believed that the powdered material is suitable for dechlorination. The treatment with chlorine and dichlorination with carbon is fairly expensive, but is so positive in the results obtained that there is scarcely a condition it will not handle. A very good plan is to superchlorinate the water at

about the same point the coagulant is added in a filtration plant, then dechlorinate after filtration. More chlorine is required, but the extra amount is very small. It gives complete sterilization of the water in the very beginning of the treatment process, and if by accident insufficient chlorine is added, or the application interrupted for a short interval, it almost invariably will be discovered before the water passes the plant. Corrective treatment then may be applied. In so far as the removal of taste is concerned the carbon will remove the taste regardless of whether the water is properly chlorinated.

The writer is of the opinion that the continuous use of chlorine to excess in water passing an activated carbon filter is helpful in keeping the carbon in an active state. It seems that part of the adsorption capacity of the material reduces fairly rapid to a certain point, then it remains in a state whereby it is capable of removing objectionable compounds over a very long period, providing the amount of organic matter in the water is not excessive. Some are of the opinion that the organic compounds adsorbed by the carbon are attacked first by the chlorine, or in preference to the carbon. The writer has no proof of this assumption, although it seems probable.

The chlorine-activated carbon treatment should be particularly attractive to small plants where skilled supervision is too expessive. The chlorine application may be very erratic, but so long as enough chlorine is applied for sterilization the results will be good. This is not advocating a lessening of efforts to keep a constant application of chemicals in proportion to the needs, but to state that variations in the application will not result in bad tasting water. It makes an installation where almost any one can produce perfectly palatable water all the time, which is more than may be said for any other treatment.

Ozone

Ozone is regarded as a high oxidizing compound and is a very effective means of preventing taste in water. Certainly it does not produce the chlorinous tastes, and there is evidence that it is effective in lessening some of the tastes already in the water. The cost heretofore has been fairly high for a municipal supply, but it may be used to advantage in small installations where a large per cent of the water is consumed. It is not as free from interruption as beds of activated carbon, but when operating properly will give very good results.

TABLE 1

Summary of taste elimination treatments

LOCATION	AUTHOR	REFERENCE NUMBER	CAUSE OF TASTE, AND TREATMENT USED
Tastes produced by microörganisms—algae, fishy, etc.			
Olean, N. Y.	Stuart	18	Taste produced by dead algae. 0.045 g.p.g. Nuchar removed the taste
Washington, Pa.	Stuart	18	Taste produced by dead organisms. 0.09 g.p.g. Nuchar removed the taste
Appleton, Wis.	Hall	19	Taste caused from algae. Removal by aeration
Bloomington, Ill.	Spaulding	20	Taste produced by algae. Some of taste removed by Nuchar
Mamaroneck, N. Y.	Potter and Klien	22	Taste caused from algae. High prechlorination in connection with potassium permanganate removed the taste. 0.2 to 0.45
Hackensack Water Co.	Spalding	23	Fishy and vegetable tastes were produced by Dinobryon and Asterionella. Removed by 10 pounds per million gallons of Nuchar
Minneapolis, Minn.	Raab	27	Mouldy odor probably produced by Anabaena. Prechlorination to 14 pounds per million gallons removed most of odor
			Mouldy odor produced by Aphanizomenon. Not improved by 11 pounds per million gallons of chlorine. Ammonia not successful
St. Paul, Minn.	Thompson	28	Nearly all of the taste removed by aeration
Chester, Pa.	Norcom and Dodd	29	Fishy taste was removed by carbon
Hackensack Water Co.	Spalding	30	0.5 g.p.g. Nuchar removed the taste
Springfield, Ill.	Spaulding	32	Algae taste not removed by the ammonia-chlorine treatment

TABLE 1—*Continued*

LOCATION	AUTHOR	REFERENCE NUMBER	CAUSE OF TASTE, AND TREATMENT USED
Tastes produced by microörganisms—algae, fishy, etc.—*Concluded*			
Mamaroneck, N. Y.	Nordman	34	Taste from algae and dead eels not removed by superchlorination and potassium permanganate. Ammonia-chlorine treatment effective
Baltimore, Md.	Hopkins	37	Taste caused from decomposition of aesterionella and fragillaria. The ammonia-chlorine treatment removed taste except for faint woody twang
Norfolk, Va.	Fitzgerald	39	Taste from microscopical growths. Prechlorination with 0.8 p.p.m. chlorine effective at Moore's Bridge Station. Iodoform taste at 37th Street. Plant not eliminated with chlorine or ammonia and chlorine
Tulsa, Okla.	Jewell	40	Taste caused from diatoms, spirogyra and fragillaria. The ammonia-chlorine treatment not effective in preventing or removing tastes and odors. A very small amount of chlorine in combination with ammonia was sufficient to cause objectionable tastes
Chlorophenol			
New Brighton, Pa.	Goehring	15	Phenol from by-product coke plant. Ammonia-chlorine prevented taste most of the time. Taste was greatly reduced but not entirely removed when there was a high chlorine demand, but it was no worse than the water prior to chlorination

TABLE 1—*Continued*

LOCATION	AUTHOR	REFERENCE NUMBER	CAUSE OF TASTE, AND TREATMENT USED
Chlorophenol—*Continued*			
Cleveland, Ohio	Lawrence	18	Phenol from by-product coke plants. Taste prevented by use of 0.5 to 2.0 pounds of ammonia per million gallons
Bay City, Mich.	Harrison	19	Phenol from gas plant wastes. Ammonia-chlorine prevented taste. Also prevented by carbon
Toronto, Ont.	Howard	24	Superchlorination followed by dechlorination with sulfur dioxide prevented taste
Cleveland, Ohio	Ellms	26	Phenol from by-product coke plants. Taste prevented by use of 0.96 to 1.8 pounds ammonia per million gallons
Hackensack Water Co.	Spalding	30	Laboratory experiments indicated that 0.5 p.p.m. Nuchar removed the taste
Buffalo, N. Y.	Cox	31	Laboratory tests show that 1.0 p.p.m. of chlorine or greater quantities destroyed the taste in 1 hour. Ammonia-chlorine prevented the taste. Potassium permanganate destroyed chlorophenol taste, but left a slight bitter or astringent taste
Rensselaer, N. Y.	Cox	31	Phenol from coke plant. 0.06 to 0.10 p.p.m. of potassium permanganate destroyed the taste. Occasionally slight bitter taste left
Waterloo, N. Y.	Cox	31	Phenol from coke plant. 0.06 to 0.12 p.p.m. of potassium permanganate destroyed the taste, but left a bitter or astringent taste
Bay City, Mich.	Harrison	33	Superchlorination and dechlorination with sulfur dioxide nearly eliminated the chlorophenol taste, but left a dis-

TABLE 1—*Continued*

LOCATION	AUTHOR	REFERENCE NUMBER	CAUSE OF TASTE, AND TREATMENT USED
			Chlorophenol—*Concluded*
			tinctly nauseating musty or weedy taste. When applied to clear and colorless water the taste was removed. Ammonia-chlorine did not prevent taste. Potassium permanganate prevented taste
Cleveland, Ohio	Braedich	36	Phenol from by-product coke plants. Ammonia-chlorine prevented taste
Indianapolis, Ind.	Jordan	38	Ammonia-chlorine prevented taste
			Musty, stagnant, woody, marshy
Wheeling, W. Va.	Tisdale	14	Ammonia-chlorine did not remove musty taste
Huntington, W. Va.	Tisdale	14	Ammonia-chlorine did not remove musty taste. 0.35 p.p.m. Nuchar removed the taste
Eastvale, Pa.	Goehring	15	Ammonia-chlorine removed taste. 0.141 to 0.245 p.p.m. ammonia used
New Brighton, Pa.	Goehring	15	Ammonia-chlorine removed the taste. 0.141 to 0.245 p.p.m. ammonia used
Bay City, Mich.	Harrison	17	Woody and swampy tastes not removed by ammonia-chlorine, potassium permanganate or superchlorination, but removed by Hydrodarco
Rotterdam, Holland	Howard	24	Musty taste left after superchlorination removed with Norit (active) carbon
			Medicinal
Wheeling, W. Va.	Tisdale	14	Ammonia-chlorine prevented taste

TABLE 1—*Continued*

LOCATION	AUTHOR	REFERENCE NUMBER	CAUSE OF TASTE, AND TREATMENT USED
			Medicinal—*Concluded*
Jamaica, N. Y.	Hale	23	Taste probably from gasoline waste. Removed by superchlorination and dechlorination with sulfur dioxide
Springfield, Ill.	Spaulding	32	Probably from phenol. 0.5 pound of ammonia per million gallons prevented taste
			River taste
Bellaire, Ohio	Waring	21	Excess lime treatment greatly minimized the taste
Ironton, Ohio	Waring	21	Excess lime treatment greatly minimized the taste
Warren, Ohio	Waring	21	Ammonia-chlorine did not remove taste
E. Liverpool, Ohio	Waring	21	Ammonia-chlorine did not remove taste
Pomeroy, Ohio	Waring	21	Ammonia-chlorine did not remove taste
Cincinnati, Ohio	Waring	21	Ammonia-chlorine did not remove taste
Huntington, W. Va.	Waring	21	One-third g.p.g. Nuchar removed taste
			Tarry
Morgantown, W. Va.	Tisdale	14	Nuchar did not remove the taste
Chester, Pa.	Norcom and Dodd		Hydrodarco removed taste
			Miscellaneous
Morgantown, W. Va.	Tisdale	14	Caused from stagnation of the Monongahela River. 0.31 g.p.g. Nuchar and 0.5 p.p.m. of ammonia reduced the taste about 70 percent
Charlestown, W. Va.	Tisdale	14	Vile odors from high pollution. No treatment effective. Su-

TABLE 1—*Continued*

LOCATION	AUTHOR	REFERENCE NUMBER	CAUSE OF TASTE, AND TREATMENT USED
			Miscellaneous—*Continued*
			perchlorination, ammonia-chlorine, copper sulfate, aeration and activated carbon tried
Eastvale, Pa.	Goehring	15	Ammonia treated water was better than water from New Brighton where chlorine only was used, when the river water was not bad. When algae began to grow, the growth was controlled in both plants by pre-treatment. Ammonia and chlorine were used at Eastvale and chlorine alone at New Brighton. There was no taste in the Eastvale water, but a slight musty taste was noticed in tap water at New Brighton
Daytona Beach, Florida	Stuart	18	Flat limey taste from softening removed by Nuchar
Hackensack Water Co.	Spalding	23	Aldehol waste from factory. Taste referred to as iodine, carbolic, tar, etc. Superchlorination with dechlorination with sulfur dioxide partially removed taste. 0.5 g.p.g. Nuchar removed all the taste
Minneapolis, Minn.	Raab	27	Mouldy odor probably from aphanizomenon. Prechlorination with 14 pounds of chlorine per million gallons reduced odor very greatly.
Chester, Pa.	Narcom and Dodd	29	Oily, gasoline, rusty and sewage taste removed with activated carbon
Hackensack Water Co.	Spaulding	30	Laboratory experiments indicated that 1 to 4 p.p.m. of aldehol could be removed with 1.0 g.p.g. Nuchar

TABLE 1—*Concluded*

LOCATION	AUTHOR	REFERENCE NUMBER	CAUSE OF TASTE, AND TREATMENT USED
	Miscellaneous—*Concluded*		
Springfield, Ill.	Spaulding	32	Taste from melting ice. 7.0 pounds chlorine and 1.7 pounds ammonia removed nearly all the taste. Mouldy taste that appears occasionally after showers removed with 9.2 pounds chlorine and 1.6 pounds ammonia per million gallons
Delaware, O.	Waring	21	Taste removed with potassium permanganate
Lancaster, Pa.	Ruth	25	Taste other than chlorinous not given. Ammonia-chlorine removed the taste. Superchlorination gave some relief
Morgantown, W. Va.	Stuart	18	0.10 g.p.g. Nuchar completely removed taste
Wierton, Ohio	Tisdale	14	One part of ammonia to 2 parts of chlorine effective in keeping down taste
Tampa, Fla.	Lyles	35	Taste probably due to reaction of chlorine with vegetable matter. Ammonia-chlorine prevented taste. 5.6 pounds chlorine and 1.9 pounds ammonia used
Indianapolis, Ind.	Jordan	38	Subtle taste products known as musty, mouldy, etc., produced as a result of chlorination, frequently eliminated by use of ammonia
Warren, Ohio	O'Connor	41	Probably due to phenol and decomposing organic matter. Taste did not develop until after use of chlorine. Ammonia prevented the taste

Potassium permanganate

Potassium permanganate continues to be used in a few instances for eliminating tastes. It also is a strong oxidizing compound. Very good results have been reported at several places where it has been used. In a few instances the taste for which it was added was removed, but a bitter or astringent taste was left in the water. It is not believed that potassium permanganate will be used extensively in water treatment, but may be occasionally resorted to when very bad conditions occur.

EXPERIMENTS WITH TASTE ELIMINATION TREATMENTS

Table 1 summarizes the experiences with taste elimination treatments in a number of cities throughout the country, as recorded in the water purification literature. The summary does not cover the uses of ammonia to prevent chlorinous tastes. It includes tastes originally in the water and tastes made more pronounced by the addition of chlorine to the water. The table is not intended to be complete, but serves to indicate the treatment tried in a number of localities.

The rapidly increasing literature on taste-elimination treatments indicates widespread interest in the subject. The consumers of the water want it free from objectionable taste and are willing to pay the cost. The matter of taste elimination in practically all cities is now up to those operating the water works. The treatments mentioned in the table naturally cover only a very small amount of the work which has been done on taste elimination, yet it gives a very good idea of the way the problem is being attached. Such rapid progress is a tribute to the rapidity with which the water purification chemists and engineers can adapt for their needs new or improved methods of treatment.

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DISCUSSION

C. L. EHRHART:[3] I am sure all of us and particularly those who have experienced troubles with taste and odors appreciate Mr. Baylis' paper on this subject. It was certainly most interesting and in-

[3] Superintendent, Water Works, St. Cloud, Minn.

structive and I would say that if this were the only paper read, the Convention is well worth while attending.

Mr. Baylis has covered this subject probably more thoroughly than anyone else could, so it is hard for a common superintendent to add anything of value to it. However, as he says, each water supply has its own peculiarities, so I am simply going to touch on some of the high lights of our experience in St. Cloud. Prior to August, 1930, we used the post-chlorination treatment, feeding the chlorine into the filter effluent. Since that time we have used the prechlorination treatment. Our method of operation is as follows: Raw water is delivered into a perforated tank aerator and the ammonia is fed into the pipe line leading from the pumps to the aerator. At one time we fed the ammonia into the tank below the aerator, but found that better mixing could be obtained by feeding it ahead of the aerator. Chlorine is fed into the water as it passes from the aerator tank to the mixing chambers. The alum solution is introduced at the entrance to the mixing chamber. Our mixers are of the over and under type with a particularly long run to insure thorough mixing and the formation of a good floc.

Since the introduction of the prechlorination treatment, we have noticed a great change in the settling basins. Prior to that time the basins, particularly when being cleaned, had the appearance and the odors of an Imhoff tank. Now the settlings in the basin form an inert jelly-like mass and are never offensive even at cleaning time.

We had one very interesting experience when the ammonia-chlorine treatment was introduced. For about six weeks the water going onto the filters had a lower bacterial count than the filter effluent. In other words, the filters added to the bacterial count so that it was still necessary to use some post-chlorine treatment. However, the count in the filter effluent gradually decreased until at the end of six weeks it became lower than in the influent. The bacterial reduction in the settled water now averages about 99 per cent. During the first nine months of this year, the raw water had an average count of 982 and the treated water 2.4. We found that it took about five months before any residual chloramines came through the filters. This residual gradually increased until post-chlorination was no longer necessary.

This treatment, however, failed to remove all of the tastes and odors that come with the spring break-up of the Mississippi River this year. This condition caused us to experiment with activated

carbon for taste and odor control, at first in the laboratory where good results were obtained, followed by practical use in the entire supply. This resulted in a decided reduction in the lengths of the filter runs, which was overcome by the following method. Instead of washing the filters every time the head dropped, we simply broke them without opening the sewer valve. Both the influent and effluent valves were closed and wash water admitted until the level was raised 12 to 18 inches. Then after allowing a small amount of water to pass out through the filter waste, the effluent and influent valves were opened and the regular operations continued. This method restored the head without the necessity of washing. It was repeated three or four times before it became necessary to wash.

We find that the activated carbon which we use (Nu-Char No. 2) cuts down some on the residual, but does not eliminate it. We have consistently carried from 0.25 to 0.30 p.p.m. at the pumps. Due to the fact that chloramine residuals do not disappear as quickly as chlorine, we find the residuals in the business district are nearly as high as in the plant. Even the outlying districts have a fair trace.

No phenol tastes have been noticeable since the introduction of the ammonia-chlorine process. There is no question in my mind that this process will not only eliminate phenol tastes, but will also keep the basins and filters in much better shape. For some five months, we have not had a single colon show up in the samples taken from the water passing from the basins to the filters which seldom happened before this process was used. However, as stated above, the ammonia-chlorine treatment did not remove all tastes and it was necessary, in our case, to use Nu-Char in addition to effect complete removal. At the present time, we are feeding the activated carbon through a machine meant for flour mill use, pending the arrival of a type O, Wallace and Tiernan machine which has been purchased. This machine discharges the carbon into a tank of water from which it passes through a high speed pump to the point of discharge. This pump guarantees thorough mixing, which is absolutely necessary in the handling of this material. At times the use of Nu-Char proves to be rather expensive, running as high as $5.00 per million gallons when tastes and odors are at their worst. During one of these periods, we experimented with additional aeration with good results. A line was connected to the raw water line at a point just beyond the outlet of the raw water pumps and compressed air pumped into the raw water. The compressed air had about twenty seconds' contact with

the water before it was released into the regular aerator. This seemed to drive off a greater amount of odor than the regular aeration process did and undoubtedly was of some additional assistance in the control of this problem.

LARVAL CONTAMINATION OF A CLEAR WATER RESERVOIR[1]

By Clarence Bahlman[2]

The appearance of a red worm in a glass of drinking water led to unique developments which will be of interest to the water works fraternity.

Early in May a small red worm was drawn from a kitchen faucet, but at the time this was considered as an isolated and chance occurrence because no further complaints were received. Early in July, however, a surburban family hotel reported that worms had appeared suddenly and simultaneously in many of their suites.

There were no tanks at this hotel, and inspection indicated that the worms were derived from the city water mains. They were drawn from faucets at all parts of the building, collected in the flush tanks of toilets, and as many as 10 or 15 were delivered when a bath tub was half filled with water.

Since there are no open reservoirs on the distribution system serving this hotel, suspicion was directed to the clear water reservoir of the Filtration Plant. A ¼-inch tap, connected to the 60-inch effluents from this reservoir, is kept running at all times for the collection of bacterial samples. The flow from this spigot was directed through a cheese cloth screen, and in this way from 5 to 20 worms per 24 hours were collected during the 2 weeks which elapsed before the reservoir was cleaned.

With such infection of the entire water supply it is both remarkable and fortunate that complaints were not more widespread. Employees in different parts of the city made efforts to find the worms at their homes, but only a few succeeded in doing so. Most frequently the complaints came from apartment houses and buildings having a larger intake than is provided for the ordinary residence.

An examination of the clear water reservoir disclosed large numbers of the partially disintegrated skins of the worms in the lee corners,

[1] Presented before the Central States Section meeting, October 8, 1931.

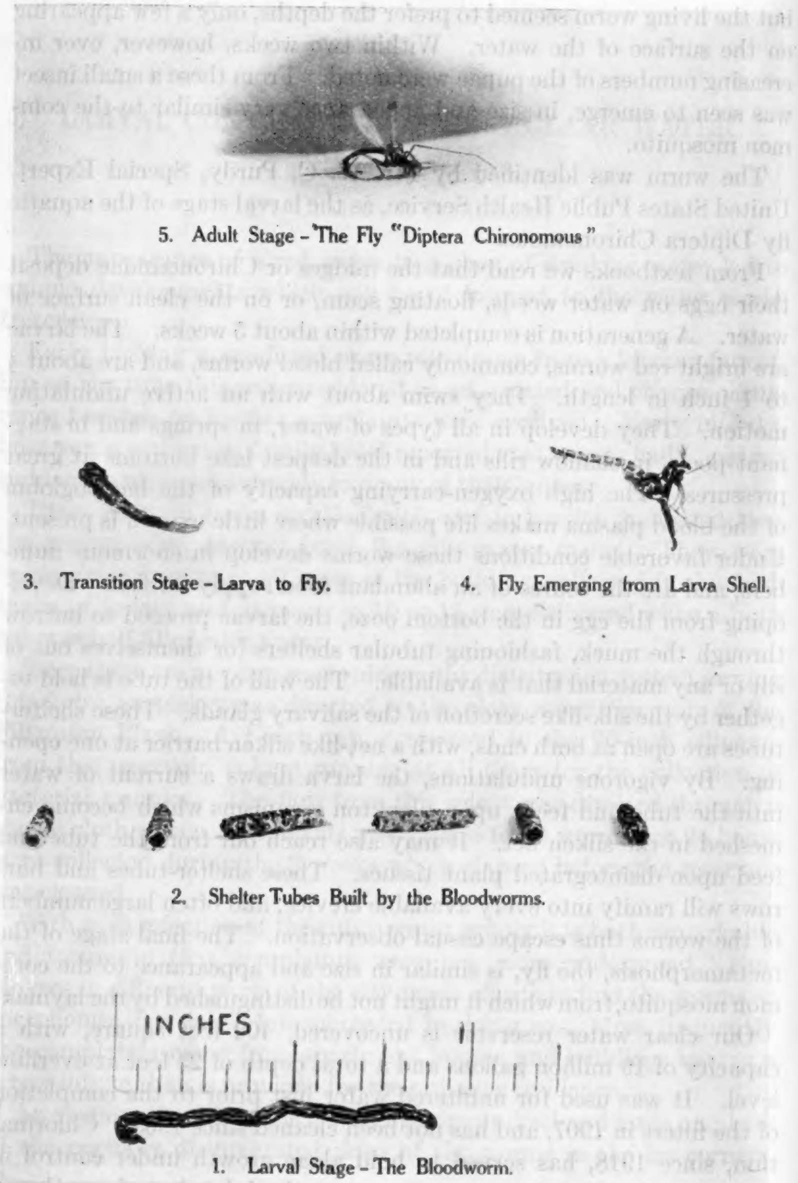
[2] Water Purification Supervisor, Cincinnati Filtration Plant, California, Ohio.

but the living worm seemed to prefer the depths, only a few appearing on the surface of the water. Within two weeks, however, ever increasing numbers of the pupae were noted. From these a small insect was seen to emerge, in size and appearance very similar to the common mosquito.

The worm was identified by Mr. W. C. Purdy, Special Expert, United States Public Health Service, as the larval stage of the aquatic fly Diptera Chironomous.

From textbooks we read that the midges or Chironomidae deposit their eggs on water weeds, floating scum, or on the clean surface of water. A generation is completed within about 5 weeks. The larvae are bright red worms, commonly called blood worms, and are about $\frac{1}{2}$ to 1 inch in length. They swim about with an active undulating motion. They develop in all types of water, in springs and in stagnant pools, in shallow rills and in the deepest lake bottoms at great pressures. The high oxygen-carrying capacity of the haemoglobin of the blood plasma makes life possible where little oxygen is present. Under favorable conditions these worms develop in enormous numbers, and are the source of an abundant food supply for fish. Developing from the egg in the bottom ooze, the larvae proceed to burrow through the muck, fashioning tubular shelters for themselves out of silt or any material that is available. The wall of the tube is held together by the silk-like secretion of the salivary glands. These shelter-tubes are open at both ends, with a net-like silken barrier at one opening. By vigorous undulations, the larva draws a current of water into the tube and feeds upon plankton organisms which become enmeshed in the silken net. It may also reach out from the tube and feed upon disintegrated plant tissues. These shelter-tubes and burrows will ramify into every available crevice, and often large numbers of the worms thus escape casual observation. The final stage of the metamorphosis, the fly, is similar in size and appearance to the common mosquito, from which it might not be distinguished by the layman.

Our clear water reservoir is uncovered, 400 feet square, with a capacity of 19 million gallons and a total depth of 23 feet at overflow level. It was used for unfiltered water just prior to the completion of the filters in 1907, and has not been cleaned since 1908. Chlorination, since 1918, has served to hold algae growth under control in about one-third of the reservoir nearest the inlet, but there always has been some growth toward the outlet side, where free chlorine is least in amount.



5. Adult Stage - The Fly "Diptera Chironomous"

3. Transition Stage - Larva to Fly.

4. Fly Emerging from Larva Shell.

2. Shelter Tubes Built by the Bloodworms.

1. Larval Stage - The Bloodworm.

FIG. 1. LIFE CYCLE OF THE FLY "DIPTERA CHIRONOMOUS"

Algae flourished in all our reservoirs to an unusual extent in the summer of 1929, and the growth in the clear well reservoir then became increasingly more luxuriant. Again, during the prolonged drought of 1930, the growth caused an unsightly condition when large patches broke loose and had to be removed by skimming. At that time the reservoir was lowered considerably and the slopes were brushed with wire brooms and sprayed with copper sulphate. The unclean condition of the bottom then was first revealed, and the necessity of an early cleaning was indicated.

The flat plateau to the west of the reservoir is well covered with deciduous trees, although none are immediately adjacent. The prevailing winds come from the west, and any deposit in the reservoir must consist largely of wind-blown foilage. The plant boiler room also is west of the reservoir, and soot from the stack undoubtedly contributed to the contamination up to the year 1927, when boiler operation was discontinued.

When the reservoir was cleaned, within a few weeks after the discovery of the worms, little deposit was found along the inlet side, but a black sludge covered about three-fourths of the bottom to a depth, while still quite wet, of from 10 to 12 inches. This sludge was amorphous and almost of impalpable fineness, except for the skeleton framework of many maple, oak and willow leaves. The odor is best described as pig pen or strongly stagnant. The sludge was not septic in situ but rapidly became so in the laboratory. When dried, the material consisted of 58 percent of ash and 42 percent of volatile and combustible matter. Under the sludge, myriads of empty snail shells (Planorbis) were found, but no living specimens were seen.

As the water receded from the deposit during the draining process, we were amazed to see many bright red, blood colored areas on the top of the sludge. These were caused by dense masses of writhing blood worms.

The habits of the larvae, as described in the textbooks, were strikingly exemplified in the reservoir. On the under side of many large masses of pitch, which during the years had exuded and lodged on the ledges and bottom, were large grooves and bubbles harboring hundreds of worms. On the bottom, at one of the corners of the reservoir, the droppings from a gunite repair job had hardened into a large mass. A pick was required to break up this formation, which was found to be thoroughly honey-combed with small channels teeming with worms. Many of the small shelter-tubes which are con-

structed by the worm, somewhat calcified by long immersion, were observed, attached to the concrete sides and bottom of the reservoir. When crushed, the silky binder of the tube was readily seen.

It is evident that natural aerial contamination may lead to serious consequences in an open reservoir, even though the water is chlorinated to the point of bacterial sterility. Frequent cleaning will prevent the accumulation of an abundant food supply for larvae, snails and other denizens of the depths, and in this way will lessen the chances of trouble. Experiments at the local Stream Pollution Station of the Public Health Service, however, have demonstrated that the Chironomidae will deposit eggs on the surface of clean tap water in a bucket, and that the blood worm will develop in the absence of visible sediment or food supply. It seems, then, that the cleanliness of a reservoir is no guaranty that it will escape attack by insects. A complete covering of the clear water reservoir is the only means of maintaining an aesthetic water supply.

The nearest approach to our experience which has come to our notice in the literature occurred at the Champaign and Urbana Water Company, Champaign, Ill., in 1923 (W. B. Bushnell, This Journal, Vol. 13, p. 653, June, 1925). Apparently the same insect was involved. Their clear water reservoir at the time was covered with a wooden roof which was not sealed to the walls, and insects were able to enter at this point. Since covering with an insect-tight concrete roof, however, no trouble has been experienced.

CHIRONOMUS IN WATER SUPPLY

By Carl A. Hechmer[1]

The Washington Suburban Sanitary District derives its water supply from the Northwest Branch of the Anacostia River. A filtration plant at Burnt Mills with a capacity of 3½ million gallons daily and a plant at Hyattsville having a capacity of 1 million gallons daily, serve to filter and purify the water. The plant at Burnt Mills is of a temporary nature having two uncovered cylindrical tanks for filtered water storage, one 38 feet in diameter and the other 16. A dam at the plant impounds the water forming a raw water reservoir with a capacity of 30 million gallons. The plant at Hyattsville receives its water several miles below the Burnt Mills plant, no impounding works being necessary at this point. The filtered water reservoir at the Hyattsville plant is covered.

During the early part of July, 1930, when the drought was approaching its height, little worms were found in the water by the Burnt Mills operators. Some of the worms were white and others were red, the latter color predominating. They varied from $\frac{1}{32}$ to $\frac{1}{2}$-inch in length and appeared particularly alive and active. The worms were found in the impounding reservoir, generally around old tree stumps which had been submerged, in the coagulating basins, on the filters, in the filtered water tanks and a small number were found out on the distribution system, causing several complaints from water consumers. Attempts to kill these worms with high doses of chlorine and copper sulphate met with no success. The worms were bleached almost white with high doses of chlorine, in excess of 10 p.p.m., in the laboratory, yet they continued to kick and swim. The plant was taken out of service at this time due to lack of water in the stream, the distribution system being fed from other sources during the shutdown and no trace of the worms was found when the plant was put back in service several months later. No worms were found at the

[1] Department Engineer, Maintenance and Operation Department, Washington Suburban Sanitary District, Hyattsville, Md.

Hyattsville plant and no complaints were received from that portion of the distribution system served by this plant.

These red worms were identified as members of the "Chironomus" family originating from a midge fly. The identification was made by Mr. W. C. Purdy, of the United Public Health service at the office of the Maryland State Deptartment of Health. We considered covering the filtered water tanks at the Burnt Mills plant, but since the worms were not found when the plant was put back in service, probably due to the cold weather which had set in the meantime, this plan was not carried out.

The plant continued in daily service until June, 1931, without difficulty, when the stream again became low and the worms again put in their appearance. They were first discovered in the filtered water. Further investigation found them in very large numbers in the raw water reservoir. A burlap screen was constructed at the intake in an attempt to prevent them from entering the plant, but still they persisted in the filtered water. Laboratory tests on an experimental filter showed that the worms did not work their way down through the sand, either when filtering or back-washing, but that all the worms were removed in the process of filtration. Further attempts to kill the worms with chemicals were unsuccessful except in prohibitive doses. Attention was then turned to the filtered water tanks and a large number of gelatinous clumps resembling frog eggs, were found floating on the surface of the water. A number of these clumps were collected in a beaker, but attempts to float them off by overflowing the tanks were not successful, since the eggs went to the bottom of the tanks as soon as the water was agitated. Further inspection found these eggs on the filters and in the coagulating basins. The filtered water tanks and the coagulating basins were immediately pumped out and cleaned and a large number of the same red worms as occurred in 1930 were found, the larger number being in the coagulating basins. The filtered water tanks were immediately covered with a fine mesh wire fly screening, since the laboratory work and plant observations made it evident that the worms got into the tap water after filtration. No worms were found at the Hyattsville plant in 1931 in spite of the recurrence at Burnt Mills.

The eggs which were collected in the beaker from the filtered water tanks were brought into the laboratory and two days later hatched into a large number of white and reddish worms. The egg shells began to disintegrate at once causing a very foul odor in the water.

The hatched worms, together with several larger worms from the coagulating basin were taken to Dr. F. M. Root, of the Johns Hopkins University School of Hygiene, who identified them as members of the "Chironomidae or Chironomus" family, several different members being identified, particularly "Chironomus Plumosus."[2] These worms are commonly called red worms or blood worms and originate from the midge fly (Tarrypus Carneus).

The worms disappeared soon after the filtered water tanks were covered, only an occasional one being found in the raw water. In November, 1931, following a mild fall and a period of very warm weather, the red worms again put in their appearance in the raw water, in the coagulating basins and on the filters, but none were found in the filtered water tanks or in the tap water, although a very sharp lookout was kept for them by the operators. A small white worm also was found in the raw water. The red worms were again identified as "Chironomus" while the white ones were found to be "Sagomyia Plumicornis."[3] The worms lasted but a few days and soon passed away.

In December, while cleaning the coagulating basin, it was noticed that the sludge clung to the wooden baffel boards and careful inspection found this sludge covered hundreds of small gelatinous cells, in each of which was one of the red worms as previously found in the water during warm weather. These worms apparently bury themselves in the mud in the bottom of streams during winter weather.

While the worm trouble was apparently caused by the flies depositing eggs on the surface of the water of the uncovered filtered water tanks, the covering of which eliminated the trouble in the tap water, it is also evident that the drought of 1930 and 1931 had much to do with causing this trouble. The Burnt Mills plant had been in operation since 1924 with uncovered tanks and no trouble was experienced. It was apparent that the natural breeding places in swamps and ponds having been dried up because of the drought, the flies were forced to other bodies of water to deposit their eggs, even though these bodies

[2] See plate C, page 341 of the first edition of "Microscopy of Drinking Water" by Whipple, and figures 1383 and 1384, pages 914 and 915 of the first edition of "Fresh Water Biology" by Ward and Whipple. Also figure 7, page 8, "Die Süsswasserfauna Deutschlands," by K. Grundberg. (Published by Gustav Fischer, Jena.)

[3] Reference pages 90 and 91, figure 104, "Die Süsswasserfauna Deutschlands," by K. Grundberg.

of water were less desirable because of exposure, clearness and agitation.

The experience at Burnt Mills confirms the causes of trouble at Cincinnati as reported by Bahlman,[4] who found that "Chironomus" was the red worm that caused trouble in the tap water in that city. The trouble was also traced to an uncovered filtered water reservoir. His conclusions were: "a complete covering of the clear water reservoir is the only means of maintaining an aesthetic water supply."

Enslow,[5] reports some experience with the midge fly at Gatun, Canal Zone, and also the appearance of this same fly at Back River, near Baltimore in 1931, but no definite information as to their habits or elimination was given.

Amsbary[6] also made reference to red worms in the water supply at Champaign, Illinois. Covering the clear water reservoir with an insect-tight concrete roof eliminated the trouble.

[4] This Journal, page 660.
[5] Water Works and Sewerage, November, 1931, page 333.
[6] Journal, May, 1928, page 525.

TRUNK MAIN SURVEYS[1]

By Edgar K. Wilson[2]

In every city it is becoming increasingly necessary to make more and more investigations to give the officials of the water system the data which will enable them to obtain the maximum efficiency from their plants. The day is past when important mains can be arbitrarily laid down on a blue print with a red pencil, because such procedure involves in almost all cases either too great capacity, requiring greater expenditures than are justified, or too little capacity, requiring duplication in too short a time.

Such a method of laying out new work has resulted in the curious locations often found, especially in large cities, of short lengths of large mains, sometimes fed by very small pipes, sometimes feeding mains of only a small percentage of the capacity of the feeder, sometimes both. The original idea back of these mains is usually hard to see; but in many cases an official has made up a somewhat definite scheme for future development, of which these mains are the first construction, laid perhaps because of new paving. Before the development has had a chance to proceed along the lines of his ideas, a change of administration has replaced the official with someone of radically different ideas and the original plan is forgotten, leaving only these few traces.

The importance is evident of having a permanent plan, designed, not according to the ideas of an individual who may or may not have some ideas of the hydraulics of pipe lines, but with full knowledge of the hydraulic conditions of the mains which are already in the system, and with the opportunity of checking the results as construction progresses.

Long experience in the water works distribution field led the engineers of the Pitometer Company to believe that it was possible to develop a service by which cities could learn the facts about the large feed mains of the water system, so that the local engineering force

[1] Presented before the Central States Section meeting, October 8, 1931.

[2] Chief Engineer, The Pitometer Company, New York, N. Y.

could use the data in forcing the mains to function efficiently. This service has been welcomed by many of the larger cities to which it has been offered; and their engineers have appreciated the fact that they have been provided with actual information regarding the direction and amount of the flow of water and the condition of the interior of the mains.

The larger cities have been mentioned because this service is especially designed for cities large enough to maintain an adequate engineering force capable of taking care of the design work of the system.

In the smaller cities it is often difficult to differentiate between trunk mains and distribution mains, since the former are practically only larger distribution mains. This is also true in the larger cities to a somewhat less degree. While it is apparent that mains as small as 12-inch would usually be classified either as sub-feeders or distribution mains, it is often necessary to investigate pipes of this size, in order completely to analyze the flows in the larger pipes to which they are connected; and this has been our practise.

Before going to the description of instruments and methods it should be understood that laboratory accuracy is not claimed for these tests. While it may be of interest to know within 1 or 2 percent the value of the friction coefficient, such accuracy is not essential for practical work, while the cost of opening pavements, tapping mains, and professional services will be kept within bounds, and at the same time longer stretches of main will be tested under operating conditions with crosses, tees, and other specials in place.

A TRUNK MAIN SURVEY

The work of the Trunk Main Survey is divided into two parts, the measurement of the flow through the pipe, and the determination of the value of the Williams-Hazen coefficient.

The first of these—the measurement of flow—is perhaps more important than the second, since it often brings to light peculiar conditions contrary to what might be expected; and to a considerable extent indicates what remedies may be applied to correct faults.

In making these measurements the length of line to be tested in one operation depends on the number of important laterals taken from it, and on the number of recording Pitometers available. These instruments are set at each end of the line and on each of the important branches and simultaneous twenty-four-hour measurements are

made of the flow. The number of the instruments is ordinarily limited to 6 since a larger number would be more than could be operated properly at one time. It has been found, however, that the flow from 12-inch branches from a large feed main varies too little from day to day to affect the results materially; so that it is possible, except where local conditions clearly show that a considerable error would probably result, to make additional measurements within two or three days after the principal measurements have been made.

These measurements give the consumption between the ends of the test section, the difference after the flows through the important branches have been algebraically subtracted from the initial flow, being the amount taken through the smaller branches or used along the feed main itself.

These measurements are run under actual operating conditions with all valves open.

The second part of the work consists in the determination of the value of *C* in the Williams-Hazen formula. For this a specially calibrated series of Bristol recording pressure gauges is used. The charts are divided into divisions representing 2 feet head of water and are sufficiently large that they my be read to about $\frac{1}{2}$ foot directly from the chart. Each gauge has a range of 150 feet head of water and there is a 10-foot lap between each two sets of gauges. To spread the record as much as possible the driving clocks are geared to revolve the chart once in 4 hours. To avoid jars in transportation about the city, the gauges are carried in carefully padded cases and they are checked up by a dead weight tester before and after each set of tests.

The tests are run with gauges at each end of the section, and with side valves closed, for a period of about thirty minutes, and at the same time velocity readings are taken by means of a Pitometer at the same gauging points. This eliminates all uncertainty as to the velocities during the test—an important point when it is remembered that flows very often do not follow the expected routes.

Elevations are provided at the gauging points by the city, and transferred to the gauges either by direct measurement or by hand level from a bench mark on the curb close by.

The principal sources of error in these tests are low velocities and short lengths of pipe, with corresponding small variation in head. In such cases an error of only $\frac{1}{10}$ foot may change the coefficient quite considerably one way or the other. It must be remembered, how-

ever, that in such cases the main is doing very little work and this knowledge is valuable, if it is desired to obtain greater efficiency.

Upon the completion of the test the charts are carefully averaged and the computation is made by means of the Williams-Hazen hydraulic slide rule. The results are recorded on blanks providing for all details of the test so that, if desired, the data may be used in other formulas which may be standard in a given city.

RECORDS

The data recorded and reported on, are like the work divided into two parts. The first part gives the details of the measurement at each point in the section under consideration, the general location and the test number being included in the title of the sheet. This is as follows: Chart Number (referring to the flow charts which accompany the report); Location of each gauging point; Pipe Size; Pipe Coefficient (ratio of mean to center velocity obtained from a traverse of the pipe); Direction of Flow; Total, Maximum, and Minimum Flows (in rates of 1000 gallons per day); and the Maximum Velocity found during the twenty-four hour period. A note is added at the end of this table showing the number and sizes of the connections along the trunk main which were not measured directly.

Under the section "Loss of Head Tests" are given the following items: Location of each point; Calipered size of the pipe; Velocity at each end; Head at each end as obtained by the pressure gauges; Elevation of each gauge; Water level (sum of head of water and elevation) at each point; Total loss of head; Length of test section; Slope in feet per 1000; Coefficient; Date pipe was laid; and corresponding coefficient from Williams-Hazen hydraulic tables. This last is inserted simply for comparative purposes and is in no sense a criterion of what a pipe might be capable of doing if obstructions, including tuberculation and corrosion, were removed.

While it is of value to have on record all these various data, it is not convenient for reference where a considerable area is under examination. For this reason the results of the tests are arranged on a trunk main map of suitable size, so that the essential features may be readily studied in their relationship to each other. A break in the line representing the trunk main shows the approximate location of the gauging point, and an arrow head on one side or the other of the break shows the direction of flow. Close beside the break is a tabulation of the Total Daily Flow; the Maximum Rate; the Mini-

mum Rate; and the Maximum Velocity encountered during the twenty-four-hour gauging period. In cases where reversals of flow occur, arrow heads are placed on each side of the break in the line, and the tabulation includes the total flow, the maximum rate of flow, and the maximum velocity, in each direction; the minimum rate, of course, being zero at the point of reversal. The value of the coefficient *C* is shown near the center of the test section.

EXAMPLES OF FINDINGS

A few instances of what the Trunk Main Surveys have made evident and where economies of operation or construction have been effected, may be of interest.

In City A a 20-inch main had been projected to supply a section where poor pressures prevailed. It was found that there was already unusually large main capacity, with so small a loss of head that the proposed main would give only a pound or two increase; and that the trouble was entirely due to a difference in elevations which the low pressures maintained in the city could not quite overcome. While the $20,000 saved by the elimination of the proposed main was largely used for a booster station, the final improvement was of real value, while the proposed main would have given practically no relief.

In City B there existed a long 30-inch main which after looping around the outskirts of the city, terminated near the business center at a junction with the 36-inch feeder leading directly from the pumping station. On account of lack of pressure at the extreme outside point of the loop where a large manufacturing plant was located, it was proposed to lay a 30-inch from the station directly to that point to supply proper fire protection. The survey showed that the water was running completely around the loop and feeding into the business district in considerable quantities. An investigation of the direct 36-inch main disclosed a valve broken and partly closed which accounted for part of the trouble; but computations indicated that a proposed parallel main already included in design for immediate future work would relieve the situation entirely. The proposed 30-inch main was therefore not needed and its cost, $175,000, was saved.

In City C it was found that a reservoir on the far side of the high value district from the pumping station, and therefore in an ideal position to serve that district in case of a large fire, could not come into action, due to lack of feed mains of adequate capacity until the pumpage at the station had already reached almost the total amount

required by the Underwriters. A proposed 36-inch main of reasonable length will give the capacity necessary to allow this reservoir to function and take up its share of the load at about the same draft as will begin to be felt at the pumping station. Further changes to be made in pressure boundaries will put the reservoir into actions before the pumps are called upon to increase the flow.

In City D a closed valve in the main feed between the pumps and the reservoir was found, which forced the water through a lengthy detour; and decreased the main capacity between the two points. While the system was fed about equally through the day from the two points, and no serious pressure drops were noticed due to the closed valve, conditions might easily arise which would cause serious trouble.

In City E a long 16-inch main was doing little or no work, because there was insufficient outlet at its far end, although the pressures were poor, especially during the sprinkling season. A small booster system put this main into operation and an adequate supply of water was delivered for ordinary consumption and for fire protection as well.

In City F two 48-inch mains from the filter plant were found to be carrying water in the ratio of about two to one, although their inlet and outlet arrangements were practically identical. It was found that at a certain point in one of these mains an old reservoir and pumping station had been dismantled and that the old piping had been left in the ground, forming an intricate path with uncertain valve conditions for the water of this main. Cutting out this old piping and making a direct connection past it brought this main into proper efficiency, at the same time reducing the velocity in its mate with corresponding advantages in the matter of friction losses.

In City G water was pumped from a reservoir and out into the system. The Trunk Main Survey showed that several million gallons daily of this water, after circling through the distribution, was returning to its original reservoir through a 48-inch separation valve accidentally left open.

In City H it was found that two 40-inch mains were doing more than their share of the work, while a 48-inch main nearby was carrying only a part of what it should have done. This was largely due to the lack of outlet capacity for the 48-inch which forced a considerable amount of water received from the conduit through branches to points where it was not particularly needed. A 36-inch main of comparatively short length was proposed to carry this water towards the

center of the city, and such a main would also release considerable capacity of one of the original 40-inch mains for rapidly increasing consumption in its adjacent territory.

In City I a 42-inch main had been recommended to run to the center of the business section with a 36-inch extension beyond that point. Our tests proved conclusively the need and wisdom of the 42-inch, but showed that the 36-inch extension, about 5,000 feet, would not be needed for some time to come, since the area to be served was already so adequately supplied that water was fed back towards the pumping station into the business section.

In City J a test on the 36-inch main feeder from the reservoir to the center of the city was found to have a coefficient of only 26. An investigation showed that there was a serious air pocket at a point a few hundred feet from the reservoir. A 1-inch corporation cock inserted in the main at this point blew nothing but air for about five minutes, after which another test showed the coefficient as about 100, which is the figure given in the Williams-Hazen tables for a pipe of the same age.

In City K two large mains are connected to feed the reservoir, but one of these was closed off due to probable leakage caused by land slips; while the other carried less than it should have done since it discharged into the reservoir over a weir box. On what might be called the outlet side of the reservoir two mains of equal size, about sixty years old were found to feed both into and out of the reservoir. The coefficients of these mains showed that they were badly in need of cleaning. In order to make full use of the first mentioned mains, it was proposed to lower the end of the one discharging over the wire box and to test out the second to see if it would carry water or should be definitely abandoned. With increased feed from this side of the reservoir, each of the outlet mains in turn could be taken out of service for cleaning, very greatly increasing their carrying capacity and increasing pressures near the center of the city when the draft is heavy.

The above instances will be sufficient to show a considerable variety in the discoveries made during the course of trunk main investigations. Great care is observed in all the tests and if a coefficient seems to be abnormal, the test is repeated. If the second test checks the first and the coefficient seems too low, a checkup of the valves is made, or perhaps the section is divided into two or more parts, a new test being made for each section to localize the trouble.

After the survey is completed the report is submitted with comments on the results of the tests and recommendations for betterments, these being for immediate needs. The results are then available for design; and the benefit is progressive. After work designed has been constructed remeasurements of flow may be made immediately, covering a sufficiently large area to show the results of the change. With these results transferred to the map the data are again complete for the next step in the improvements. This process may be continued indefinitely throughout the construction of an entire program of betterments.

The development of this type of survey has, we believe, placed an instrument of considerable value in the hands of water works officials who wish to operate their plants efficiently, to serve their patrons adequately, and to obtain the greatest return for their expenditures.

INSTALLATION AND MAINTENANCE OF GATE VALVES[1]

By C. E. Angilly[2]

Gate valves for water systems have been in use in this country since early in the 17th Century. Mr. H. G. Ludlow designed the double disc parallel seat gate valve in 1866 and in 1867 Mr. S. J. Peet designed a valve of the double disc type with a conical spreading wedge. In the same year Mr. Z. E. Coffin brought out the first double disc valve using the tapered seat instead of the parallel seat and in 1869 Mr. J. C. Chapman brought out the solid wedge type.

A Standard Specification for Valves was adopted by the American Water Works Association on June 24, 1913, and since that time the manufacturers of gate valves have continued with the improvements in both workmanship and manufacturing processes, using better materials and operating features. Wherever a certain manufacturer's valve has given satisfactory service for a number of years in a certain locality, the tendency is for the user of the valve to object to any changes in the type or manufacture of valves which he is to use.

Several cities have adopted the policy of preparing their own drawings and specifications and thereby eliminating competition except as to the manufacture of that particular valve. The value of interchangeable parts, local conditions, certain definite ideas as to how a valve should be made, and the necessity of eliminating inferior competition are the causes that lead municipalities or water companies to adopt their own patterns for gate valves.

The elimination of competition on bids for gate valves usually results in increased costs and for that reason specifications must be so written as to invite competition and also clearly to show that the inferior valves do not comply with the specifications.

Where the award of contract for gate valves is left to the Purchasing Agent the award will usually go to the low bidder without much attention being given to an investigation of the valve offered. A

[1] Presented before the California Section meeting October 30, 1931.

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catalog reference and a statement by the bidder that his type of valve complies with the specifications usually supplies the Purchasing Agent with sufficient information to determine the award.

Large orders of valves usually show a considerable saving, especially at the present time when the demand and cost of manufacture are low.

Gate valves are divided into two general classes, rising stem and non-rising stem. The use of the rising stem is limited on account of the excessive head room required and is not adaptable to underground service.

These two general classes are divided into two types: the solid wedge, taper seat, and double disc, parallel seat.

Gate valves of both the solid wedge type and the double disc type are commonly used, but the majority of valves in use are of the double disc type. The solid wedge valve is usually specified for sizes less than 12 inches in diameter and the double disc valve for sizes of 12 inches and larger.

There is an increasing demand for the square bottom valve. This valve is of the double disc type and is designed with long guide lugs at each side of the disc casting, with the disc guide ribs cast integral with the body and bonnet. This type of valve is often specified where there is frequent operation of the valve or where it is desired to leave the valve in a partially opened or closed position.

The type of valve to be specified as well as working and test pressures are determined from operating conditions.

The manufacturers of gate valves differ in the grades of cast iron and bronze used in their gate valves and in the operation and wedging devices. The specifications should be worded to permit variation in the use of materials and wedging devices within certain limits if such variations are not objectionable.

Cast iron is usually specified for the body and bonnet of the gate valve. The American Society of Testing Materials Specifications A-126-30 Class A for gray iron castings requires a minimum tensile strength of 21,000 pounds per square inch and for Class B, sometimes referred to as semi-steel, a minimum tensile strength of 30,000 pounds per square inch. Ferro steel and other process metal have tensile strength of 33,000 pounds and upwards.

The wall thickness of the body and bonnet is usually designed with a factor of safety of not less than five. Ribbing is used to advantage to reduce the thickness on the heavy pressure valves.

The American Water Works Association Specifications require a tensile strength for bronze stems of not less than 45,000 pounds per square inch. Many of the manufacturers use a bronze of not less than 55,000 pounds tensile strength and manganese bronze with a minimum tensile strength of 70,000 to 80,000 pounds per square inch can be obtained when specified. Seat rings that are screwed into the body of the valve are usually of a soft bronze with a tensile strength of about 35,000 pounds per square inch. When solid bronze working parts are required a hard bronze of 55,000 pounds tensile strength is usually specified for the discs, wedges, hooks, stem and stem nut.

The design of the discs is important as any permanent distortion of the disc will result in damage to the seat ring.

The types of spreading mechanism for double disc valves are the bottom wedging type and slide wedging type. A large majority of the manufacturers of double disc valves feature the bottom wedging type, with mechanism so arranged that the disc is not forced against the seat ring until directly opposite the opening.

In order that a fair comparison of the bids be made it is necessary for the engineer to have full details of the valve proposed to be furnished.

The insertion of the following paragraph in the specifications will enable the engineer to make such a comparison:

Contractor's Specification

Each bidder shall attach to his proposal and make a part thereof of specifications to be designated "Contractor's Specifications" which shall consist of combination foundry and shop detailed working drawings of the gate valve he proposes to furnish, with a statement thereon showing the tensile strength, compressive strength and hardness of the bronze, and the tensile strength of the cast iron he intends to use and the net weight of the valve.

When practical, the bidder should be required to submit samples of the valve he proposes to furnish.

The sample shall be tested by the Engineer to the specified working water pressure and shall be water tight when closed and shall operate freely, smoothly and to the satisfaction of the Engineer. The Engineer may subject the sample to such other tests as he may deem necessary, including the maximum hydrostatic test to determine the adaptability and suitability of the sample to the service required.

The test made on a number of different makes of valves, at the

same time under maximum working conditions, will disclose the objectional operating features that are present in a new valve.

Whenever a certain manufacturer's valve has been found to be defective when placed in service, it should be eliminated from consideration in the award until corrective improvements have been made.

INSTALLATION

The number of valves in a large trunk line is necessarily reduced to the minimum requirements on account of the cost of installation. Each large trunk line requires separate study in regard to possible damages to the line, the location of feeder connections and the possibility of supplying the main from other sources. The practice of using valves one size smaller on large lines is standard for most cities and the additional friction loss is small.

Modern improvements in tapping devices for making service and gate connections without interruptions in supply have reduced the number of gates required. The use of one valve on connections from large trunk lines to cross lines has considerable advantages where the cross line may be supplied from other sources.

On water lines 12 inches and smaller in diameter the size of the valve is not reduced and the valves are so spaced as to require a minimum number of gates to be closed and as small an area as possible segregated in case of interruptions. Usually two valves will be required at each intersection, but locations and number will vary according to the conditions.

Where possible gate valves should be located in reference to the property lines and an accurate location and description of the valve recorded and be available at all times for leak crews and others required to operate the valves.

MAINTENANCE

Under normal use a valve should remain in good service as long as the pipe line in which it is installed. This can only be accomplished by the use of a properly designed valve, using good materials and periodic inspections.

Minor repairs to valves will permit their remaining in service over a much longer period of time.

All of the larger valves should be operated once a month and their condition recorded. In business or heavily populated districts all valves should be operated at least every ninety days. In the outly-

ing districts where the failure of the valve to operate would not be serious, the time between inspections may be for much longer periods.

The operation and inspection of valves will disclose minor defects that can be readily repaired, and will also prevent the wedging mechanism from becoming "frozen" into positions.

The finding of a valve in the system that will not operate during the inspection may often eliminate serious trouble that could occur at a later date had the valve not been repaired.

Valves removed from service on account of the removal of a line can usually be cleaned and repaired and returned to service. The condition of the valve so removed should be especially noted as it represents the condition of similar valves in the system and such changes as are required to eliminate or minimize the defects should be made in the specifications.

AERATION WITH COMPRESSED AIR FOR REMOVING ODORS

By Ross A. Thuma[1]

The problem of the removal of odor and taste asserts itself in nearly all public water supplies derived from surface water, and in many underground sources. In discussing this problem it has always seemed to the writer that a sharp distinction between odor and taste should be drawn. The two sensations are excited by two special senses. They are just as distinct as light and heat. The handling of the subject of odor and taste as a single subject has undoubtedly retarded a clear perception of the importance of each. The expression "odor and taste" has become so general in water works literature that one is led to think of them as closely allied. Nothing seems further from fact. The sensations of odor and taste are so closely associated in the consumption of water and food that it sometimes becomes difficult to distinguish between them. Odor is generally defined as that quality of a substance that renders it perceptible to the sense of smell. The sense of smell is excited by minute particles coming in contact with the olfactory nerves which have their terminals exposed in the lining of the nose. It follows, therefore, that any volatile gas may reach the nerves of the nose and excite the sense of smell. Taste is the sensation excited when a soluble substance is put into the mouth. The nerves of taste have their terminals exposed in the tongue. The sensation of taste may only be excited when a soluble substance comes in contact with the tongue.

Consequently, any soluble substance (sugar or salt) may when taken into the mouth come in contact with the nerves of taste, and produce the sensation of taste, while only gases (hydrogen sulfide) are capable of reaching the membranes of the nose and exciting the sensation of smell. The nasal passages connect the nose with the mouth and, hence, any material taken into the mouth may excite the sensation of smell, if volatile gases are liberated. The combined sensation of smell and taste produce the characteristic impression known as flavor.

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The problem of removing either odor or taste, as the case may be, will undoubtedly require widely different schemes of treatment. In the St. Paul public water supply the problem is that of removing odor, and the discussion in this paper will be directed to that end.

THE SOURCE OF THE WATER SUPPLY

The principal source of water supply is from the Mississippi River. The water is led from the river to the water purification plant through a chain of four lakes, and the supply is further augmented by pumping water from a second chain of lakes into the primary chain. The water pumped from the Mississippi River into the primary chain of lakes over a five-year period (1925 to 1929 inclusive) amounted to 97 per cent of the volume taken out at the water purification plant. The water is pumped from the river at a point 10 miles north of the Twin Cities, from which point it is conducted by way of a reinforced concrete conduit 8.5 miles east, and emptied into Charles Lake. The maximum elevation of pumpage between the river and Charles Lake is about 115 feet.

Charles Lake is a small, shallow lake entirely surrounded by swampy, boggy land. The shore lines extend a considerable distance back from the lake and are covered with reeds, rushes and high weeds. The area of the lake is approximately 25 acres. The water flows from Charles Lake by way of an open canal a distance of about 0.5 mile to Pleasant Lake.

Pleasant Lake covers an area of approximately 1000 acres and has a maximum depth of 35 feet. The shores of the lake are covered with a growth of small timber. The shallow water along the shore and nearly all of the lake bottom is covered with a heavy growth of vegetation. The reeds and the weeds grow in considerable abundance in the shallow bays, one of which covers from 40 to 50 acres of land. The vegetable matter has accumulated to from a bog and some peaty land. For the past three or four years the Water Department has cut out a portion of the weeds and rushes along the shore line of the lake. The water flows from Pleasant Lake by way of a conduit about 0.5 mile long to Sucker Lake.

Sucker Lake is a shall shallow lake entirely surrounded by bog and peat land. The bottom of this lake is completely covered with a deep layer of vegetable detritus in a state of decomposition. If left to itself, the surface of the lake will practically cover over with a vegetable growth in the summer months. For the past few years the

water department has cut the weeds out of the channel in order to facilitate the flow of the water through the lake. The water flows from Sucker Lake by way of a canal cut through a peat bog for a distance of approximately 2 miles, where it enters Vadnais Lake.

Lake Vadnais covers an area of approximately 600 acres, and has a maximum depth of 60 feet. The Water Department owns the lake shores from which the native timber has been removed and the land replanted in evergreen trees. The lake has a sandy bottom, but it also has several bays, the bottoms of which are covered with vegetable growth. For many years the reeds and the weeds along the shore have been cut out and removed from the lake. However, the underwater vegetable growth contributes a large amount of organic matter to the water. Lake Vadnais has been treated with copper sulfate for the eradication of algae for the past fifteen years.

The water flows from Vadnais Lake by way of a 90-inch reinforced concrete conduit a distance of 4.5 miles to the water purification plant. The combined distance traveled by the water from the river to the water purification plant is approximately 25 miles. The time required for the water to travel from the river pumping station to the water purification plant is rather difficult to estimate. The course followed by the water through the lake system is of such a nature that the amount of displacement within the lakes would be problematical. The minimum time required for the water to travel from the inlet of Lake Charles to the outlet of Lake Vadnais is estimated at 2 weeks.

THE CHARACTER OF THE WATER

The lake system functions as huge impounding reservoirs for the river water. The character of the river water changes slightly in passing through the lake system. The physical properties of the water undergo some little change in passing through the lakes. The turbidity and the color of the river water are reduced in travel through the lakes.

The odor of the water is probably very little influenced by its travel through the lake system. The average estimated loss of odor from the river to the inlet of the purification plant is 11 percent. The odor is not reduced at every season of the year. In some seasons the odor increases while at other seasons the odor is decreased in passing the river water through the lake system.

The chemical components of the water entering the lake system are

apparently little changed in moving through the lakes. The principal difference is that sudden changes are avoided. For exemple, in the spring of the year when the ice breaks up in the river, the alkalinity may be reduced in the neighborhood of 100 p.p.m. in twenty-four hours time. The lake system acting as a buffer will reduce the change in the plant influent to from 10 to 25 percent of that in the river over a period of weeks.

The biological fauna and flora of the lake system have not made any noticeable change with the introduction of the river water into the lake system. The river forms of microörganisms have made little or no alteration in the predominating forms in the lake system. The seasonal variations interpose a factor in determining the cycles of microörganisms so that a considerably longer period will be required to arrive at a fair conclusion as to the influence of the river water on the microscopic forms of the lakes. The predominating types of algae grow luxuriously in the lake water every summer season. Our investigations show that the algae content of the water, measured in standard units, rapidly increases as the water passes from the river to Lake Vadnais or the Purification Plant influent. For the past five years algae counts on the river water have been made at intervals of ten days, while on the lake system the counts were made at shorter intervals.

A summary of the microscopical data shows that the number of standard units of algae in the river water seldom exceeds 1,500 per cubic centimeter, while at the outlet of Pleasant Lake the number may rise to 4,000 or 5,000, and at the outlet of Vadnais Lake or the plant influent the number frequently exceeds 8,000 per cubic centimeter. The algae growths follow each other in cycles as the temperature of the water and other growing conditions become suitable. From the standpoint of odor the type of algae and not the number appear to be significant. As a group, the cyanophyceae or the blue green algae have the reputation of contributing malodors to water. The cyanophyceae have been present in the lake water to the extent of 4,000 standard units per cubic centimeter, and have come into the plant, where they have been removed by the filters. The cyanophyceae growths were controlled in Lake Vadnais by treatment with copper sulfate up to three years ago; since that time the growths have been allowed to grow unmolested.

The lake water is high in organic matter, present in both the dissolved and colloidal state. The oxygen and the chlorine consuming

value of the water entering the plant is always high. The organic matter found in the water is the result of slow decomposition in the lake bottoms and in the water derived from bogs. The malodors cannot be removed by the process of coagulation, sedimentation, and filtration, even though the turbidity be reduced to zero (by turbidimeter) and the color to less than 10 p.p.m. The odors (90°C.) entering the purification plant range from two (faint) to four (decided). They are the common odors derived from decaying vegetable material such as swampy, earthy, musty, moldy, peaty, vegetable, fishy, grassy and aromatic.

AERATION FOR THE REMOVAL OF ODOR

In 1925 investigation was begun to find out the cause of complaints of odor and taste and to devise some means of relief. The early experiments with aeration seemed to indicate that under suitable conditions it might be valuable in removing odor from the water. The dissolved oxygen content of the water seemed to indicate that little could be expected from increasing the oxygen content of the water or that odor could not be removed by oxidation. The preliminary experiments seemed to indicate that some relief from odor could be obtained if the water were thoroughly agitated by blowing air through it. Aeration for the removal of odor and taste from water has been practiced for many years and in a variety of ways. The essential part of the process is to bring the water into intimate contact with the air in order that a transfer of malodorous gases from the water into the air and fresh odorless gases be allowed to enter the water. The process of aeration of water has been that of spraying the water through the air from nozzles, filtering the water through porous beds of broken stone, coke or shavings, falls through perforated plates, water falls, weirs, etc. All of the foregoing schemes bring the water into contact with the air in thin films and, thereby, provide for an exchange of gases. In each case a head of water would be required for aeration treatment. The providing of the additional head and other equipment would require a considerable capital outlay for aeration treatment.

Aeration by means of compressed air reverses the above process of treatment. The gases are removed from the water by forcing air from small jets through the water stream. It provides for a positive means of driving objectionable odors out of the water. The air

pressure must be of sufficient strength to break the water into fine sprays or, in other words, to make the water boil.

Just how these odorous gases are removed from the water is not definitely known. It is known, however, that the gases evolved are light and that they separate from the water easily when heated. The process appears to be one of ventilation, wherein the air passes through the water and carries with it the malodorous gases in much the same way as one would ventilate a room. That the malodorous gases are being removed by the aerator requires no technical analysis; anybody with a sense of smell can discover for himself that the odors are being removed, if he will go into the vicinity of the machine.

Mechanical equipment

The air is supplied under a pressure of from 6 to 8 pounds per square inch by a piston compressor with a cylinder 9 by 12 inches. The compressor is driven by a 30 horse power electric motor. The capacity of the compressor at its present rate of operation is 127,000 cubic feet of air (6 to 8 pounds) per day— twenty-four hours. The diffuser consists of two iron pipes 14 feet long by 2 inches in diameter, laid crosswise in the inlet end of the mixing chamber, and on the up flow side of the first and second low baffles. The pipes each have a double row of staggered holes $1\frac{3}{16}$-inch in diameter, 12 inches center to center and set at an angle of 45 degrees to the vertical. The aluminum sulfate solution is applied to the water on the upstream side of the first baffle of the mixing chamber. The violent agitation of the air tends to increase the efficiency of the chemical mix, which results in increasing the length of filter runs, and a slight reduction in the chlorine requirement. The primary function of the aerator is, however, the removal or malodorous gases from the water.

The results of aeration

The data on the river water are compiled from analyses of samples of water collected at intervals of ten days. The data for the plant influent and the plant effluent are the results from samples collected daily. In order to reduce the bulk of the data I am using the average by the year in table 1. The odor was determined according to the Standard Methods of Water Analysis method for odor at 90°C.

The year of 1926 was divided into two sections: the period from January to August indicates how the odor was removed by the ordi-

nary treatment consisting of coagulation with aluminum sulfate, sedimentation, filtration and chlorination; the period from September to December indicates how the odor was removed when aeration was added to the above treatment.

The percentage gain or loss shows that in every instance with the exception of the period from September to December, 1926, the odor was reduced in passing through the lakes. The losses of odor from the water in passing through the lakes varied from 3.5 to as high as 20 percent. The percentage loss of odor in both passing through the lakes system and purification treatment indicates that, without aeration, the percentage of odor removal is 43, while with aeration added to the treatment the odor removal is increased to a minimum

TABLE 1
Data on removal of odors

YEAR	ODORS			GAIN OR LOSS—PERCENT		
	Mississippi River	Plant influent	Plant effluent	River to plant influent	River to plant effluent	Plant influent to plant effluent
1926 (Jan.–Aug.)	2.8	2.6	1.6	−7.1	−43	−38
1926 (Sept.–Dec.)	3.5	3.8	0.7	+8.6	−80	−82
1927	3.5	2.8	0.7	−20.0	−80	−75
1928	3.0	2.4	0.5	−20.0	−83	−79
1929	2.8	2.7	0.5	−3.5	−82	−81
1930	2.6	2.4	0.4	−7.7	−85	−83
1931	2.9	2.5	0.2	−14.0	−93	−92

of 80 percent. In 1928 a change was made in the baffling system of the plant which improved the efficiency of the mixing, and appeared to reduce the odor slightly. In the autumn of 1930 ammoniation was added to the scheme of water treatment and again the odor was reduced. The odor of the plant effluent, averaging 1.6, was sufficient to cause many water consumers to complain of bad odor or taste. The removal of the odor by aeration removed the complaints of "bad taste." From September, 1926 to the beginning of 1928 the odor remaining in the plant effluent averaged 0.7 which was sufficient improvement to eliminate complaints of bad odor or taste. From the year of 1928 to the latter part of the year of 1930 the water had an odor in the plant effluent of 0.5. The introduction of ammoniation in the autumn of 1930 further reduced the average odor of the

plant effluent to 0.2. If the river water is taken as 100 percent, the odor removed by passing the water through the lake system plus purification treatment shows an average loss of odor ranging from 43 to a maximum of 93 percent. If the plant influent is taken as 100 percent, the removal by treatment alone ranges from 38 (without aeration) to 80 percent (without ammoniation) and finally to a removal of 92 percent with full treatment.

In the period from September to December, 1926 the average odor of the water increased in passing through the lake system, but the average percentage removal from water treatment also increased, which seems to indicate that the percentage of gain or loss of odor in passing through the lake system has little to do with the final outcome of odor removal.

The cost of aeration

The capital outlay for the aeration plant, including labor for installation, amounted to $1,600.00. The annual operating cost, exclusive of labor for operating and overhead, is $1,730.00. A capital charge of 4.25 percent for interest and 15 percent for depreciation will amount to $308.00, making a total annual charge of $2,038.00. For the past six years the plant has delivered 46,500,000 cubic feet of air (under 6 to 8 pounds pressure) per year, which was used to aerate 8,500,000,000 gallons of water per year. The average cost of aeration, then, was 24 cents per million gallons of water. The rate of water aerated has been from 15 to 52 millions of gallons per day. The maximum average per day for the month of July, 1931 was 40,000,000 gallons. The removal of odor was accomplished for all rates up to 52,000,000 gallons per day. It seems, therefore, that the equipment could have aerated a considerably larger volume of water and thereby the average cost would have been decreased. The average rate of aeration for the six-year period amounted to 5,300 cubic feet of air per million gallons of water. The minimum application of air was 2,500 cubic feet per million gallons. The aerator requires no additional help for operation; the only attention required is oiling once a day.

AMMONIATION WITH AMMONIUM SULFATE

In the summer of 1930 experiments were commenced with the application of ammonia to the water for further removal of odor. Ammonium hydroxide was added to the aluminum sulfate solution and

the mixture fed into the water at the point of aeration. The ammonium hydroxide was inconvenient to handle in the plant and was subsequently abandoned and ammonium sulfate selected as the source of ammonia. The ammonium sulfate treatment was inaugurated on a plant scale in October, 1930.

The data for the year of 1930 show that the average odor of the plant effluent was 0.4, and a total removal of 85 percent of the odor for the year. The year of 1931 shows that the odor removal has been more successful in connection with the ammoniation treatment. The average odor of the water leaving the purification plant is reduced to 0.2 and 93 percent of the odor removed. The average rate of ammonia treatment has been 0.2 p.p.m. The application of liquid chlorine has been from 0.36 to 0.84 p.p.m. The ratio of ammonia to chlorine did not seem to be of any significance.

The presence of the ammonia in the water seems to prevent the formation of odor from stagnation in the dead ends of the pipe lines, and, also, to enable the residual chlorine to carry further out into the system. The water requires a considerable amount of time to travel from the purification plant to the distant ends of the mains, and, accordingly, must have the odor reduced to a minimum.

The incorporated area of the city covers approximately 56 square miles, and has on an average about 5,200 inhabitants per square mile or 460 people per mile of water main. The City Water Department has located storage reservoirs at strategic points on high ground throughout the city. The reservoirs have a capacity sufficient to provide a forty-eight hours supply of water. The large reservoirs and long pipes prolong the time the water is in storage after leaving the purification plant in travel to the consumer. The long period of stagnation in reservoirs and in mains requires that the water be highly purified.

CONCLUSIONS

The odor of the water may be reduced by means of aeration to a point where it will not be noticeable to the water drinker. The maximum amount of odor a water consumer would tolerate without complaint would doubtless vary widely. In our experience, however, complaints disappeared rapidly when the odor of the water was reduced below an average of one.

The storage of the river water for two weeks or more in the lake system produces very little change in the odor. The percentage of

odor removal by aeration is approximately the same whether the water gains or loses odor in passing through the lake system, i.e., storage in the lakes has little or no effect on the removal of odor by aeration.

The initiation of pre-ammoniation in conjunction with aeration has served to reduce the odor to the minimum of 0.2 or a removal of about 92 per cent of the odor. Our experience in this plant indicates that either aeration or aeration in conjunction with pre-ammoniation provides a satisfactory, economical, and efficient method of removing odor from public water supply.

THE STUB PLAN OF CUSTOMERS' ACCOUNTING[1]

By M. F. Hoffman[2]

The cardinal purpose of a public utility is to render its customers service. This service consists of an ample supply of its commodity at the lowest possible cost. That public utility corporation which can furnish the best service at the lowest rate soon becomes a leader among its competitors.

Due to constant changes in the mechanical and engineering field, it has been necessary for public utility corporations to maintain highly specialized engineering and research staffs in order to cope with changing conditions. Further, in order to anticipate future needs, recommendations of these technical experts are the basis for the improvement programs of these corporations.

With engineering possibilities being exploited to the limit, further investigation discloses the possibility of real economies in the use of mechanical equipment for accounting operations of public utilities. This paper proposes to show how real savings may be effected in the highly specialized branch of accounting for customers revenues.

GENERAL BOOKKEEPING

Customers' bookkeeping, as it was known in the old days, consisted strictly of preparing a bill for the service or commodity, and posting the charge to a ledger account, the total of which ledger accounts became a charge to accounts receivable. As these bills were paid it was necessary to enter the amount of each in a daily cash book and the total of this amount was balanced with the amount of cash received. It then became essential to post these credits to the individual ledger accounts, in the majority of cases not obtaining a correct proof of posting. When the unpaid bill became overdue it was necessary to handle every account in the ledger in order to segregate the unpaid from the paid accounts.

[1] Presented before the Central States Section Meeting, October 8, 1931.

[2] Assistant Superintendent in charge of Commercial Division, Department of Water Works, Cincinnati, Ohio.

Further, in the preparation of duplicate bills for these delinquent accounts it was necessary to transcribe the same information as was posted on the ledgers. From an accounting standpoint, while this method was practical, it was soon found to be obsolete.

Manufacturers of mechanical equipment have kept pace with the requirements of public utility corporations and have devised equipment to meet every possible operation. Bills formerly addressed by hand, and later on typewriters, requiring a large number of printed forms, are now printed on an Addressograph machine from a roll of paper. This machine prints the form of the bill, addresses and numbers the account, and perforates and cuts the bill in its complete form.

The posting of the billing information may also be handled by one of several types of equipment. For those bills requiring extension of individual items we have billing machines, which post the individual items and carry the controlling amount in the machine. There is another type of machine, known as a tabulating machine, by which method the information is arranged on tabulating cards and transcribed to the bills by a special printing machine. The first method is preferable where straight billing only is involved; the latter where, in addition to the regular billing, statistical analyses are required, which can not be obtained under the first method, except in a very tedious manner.

Manufacturers have also coped with the demand for volume production at minimum cost through other equipment, among which may be noted the electric letter opener, which can open 200 pieces of mail per minute; check endorsing machine, by which bank checks are automatically endorsed as they are listed on bank deposit sheets; postage meter machine, which not only saves in preventing wastage of stamps, but in giving a complete record of mailing for divers purposes. There are also available specific types of office equipment for every purpose, and a thorough study of this equipment to the adaptation for specific needs will enable one familiar with procedure to draft a layout which would give the greatest amount of flexibility, coördination and efficiency with a minimum of effort and cost.

CUSTOMERS' ACCOUNTING

Customers' accounting for public utilities, among which is included Water Works, was originally handled in the same manner as in general

bookkeeping. Owing to the fact that it was necessary to have available a continuous record of the customer's account by periods for which service was rendered, the original plan, known as the Boston plan, provided for the maintenance of a customer's ledger in periods of twelve months on one side of the sheet and twelve months on the reverse side, making a total record of two years. This plan was practical many years ago, but the increasing number of changes played such havoc with the sequence of the accounting that the Brooklyn plan of ledger was devised.

This plan consisted of a monthly ledger account for the consumers. The ledger was prepared from addressing machines, and as mechanical equipment was applied to billing, these sheets were matched up with bills and the ledger sheets completed simultaneously with the bills. Both plans provided for the posting of credits without proof of posting, resulting in the segregation of unpaid accounts at a given period and the complete check of operations for the entire period when an out-of-balance resulted. The Brooklyn plan also became burdensome through the creation of so many ledgers each month and defeated the purpose of the Boston plan in that there was no chronological history of the consumer's account.

Another method worthy of mention was the ledger card plan, by which means charges were posted to individual ledger cards for each account at the same time that the bill was completed. Cash credits were posted to the ledger cards and the unpaid accounts were reported through the segregation of these accounts from the paid accounts.

In the majority of cities water rents are billed upon the basis of meter readings. A meter record sheet is prepared for each account upon application for service. The initial reading is noted upon the report of the meter inspector that the installation has been completed. The sheets are routed so as to take their place in geographical sequence, enabling the meter reader to cover the greatest possible territory in the shortest period of time.

Dependent upon whether monthly or quarterly billing is the mode, the meter books are taken into the field monthly or quarterly and the meter readings noted therein. Upon return to the office the consumption of water is computed and the amount of billing extended. These books are then passed to the billing operator for the completion of bill. Shortly before this, however, bills for the area being read have been addressed and checked with meter book, to insure the billing of every account, so that the billing operator has a perfect sequence of

bills for the meter book. The bills are then completed through one of the two mechanical means previously described.

CINCINNATI METHOD

I will give in detail here the operations in the Cincinnati Department of Water Works:

An audit sheet, which will comprise 35 accounts, is inserted in the machine with a sheet of carbon paper. The bills are fed into the billing machine, and the dates of last and present readings, the numbers of the last and present readings, the consumption in hundreds of cubic feet, and the amount, are entered on the bill and office record. The amount only is indicated on what will later be known as the cashiers' stub. While a delinquent or courtesy notice has been included at the time the entire bill was printed, these are detached and filed away until required, as our experience has shown that with only 10 percent of the accounts being unpaid at the expiration of the payment date, it has been practical to remove the notice only on that 10 percent and destroy the 90 percent which had been paid at that time.

The audit sheet fits the billing machine in such manner that a complete transcript of the bill is carbonized on this record, and when the unit of 35 bills has been completed a total of the consumption, together with the amount, is tabulated, and these amounts are used for journalizing purposes. The repetition of the data on the bill on this record is purely mechanical and is absolutely correct. An operator of this machine, under the present system, averages 1,400 to 1,600 bills per day, and should it be necessary this production may be speeded materially through the use of continuous rolls of paper for audit sheets.

At the conclusion of the billing, the bills, audit sheets and meter books are referred back to checkers, who verify the posting of the data to the correct bill and prove the details of the consumption with the revenues being billed. The meter books are then filed away in fireproof cabinets specially arranged to house these records, and the bills retained until the billing date scheduled for release.

On the day prior the office records are detached from the bills, unpaid balances carried forward to the bill, and the bill run through a postage meter machine and stamped with a first-class one-cent postage permit. Incidentally, the bills are printed on Government post card stock and, when completed through the severance of the office record and delinquent notice, become the size of a perfect Gov-

ernment post card, and by having "Post Card" printed on the address side, together with the return address of the Department of Water Works, are entitled to first-class postal treatment. An advantage in the use of the post card bill is the saving effected through the non-necessity of using envelopes; that they show the time of mailing the bill, thus saving many needless controversies through the geographical arrangement for delivery by the letter carriers; and by reserving the meter readers only for reading meters. The latter advantage is very important, in that it enables the scheduling of operations without any detraction from their primary duties. The cost compares favorably with that of personal delivery, but more important than any other reason is the fact that all bills are delivered at one time.

Just before release of the bills to the customers the audit sheets are totaled, and this total is furnished the bookkeeper as a charge against "Accounts Receivable Consumers Revenues," and also against the account clerk assigned that unit. The "office records," which are commonly known as accounting stubs, are then passed to this account clerk, who becomes responsible for these accounts.

As payments are received, either by mail or at the cashiers' windows, the cashiers' stubs are stamped with the date of payment and the cashier's number, together with the bill, if the bill is returned with the stub, and these stubs are totaled at intervals to balance with the cash. Each cashier is required to complete a cash report grouping all meter revenues, regardless of districts or zones, and separating all other receipts by classes of revenues.

The stubs are then passed to a distribution clerk. This clerk separates the stubs into zones, and by means of a non-listing adding machine takes a total of each zone, and the total of these zones must equal the grand total of meter water revenues reported for each cashier. When each cashier has been balanced by the distribution clerk, a similar report is prepared in triplicate for the total of all the cashiers' collections by zones for meter revenues, and by classes of revenues for other receipts. The original of this report is furnished the general bookkeeper, the duplicate the head cashier, and the triplicate is retained by the distribution clerk for balancing with the account clerks. A bank deposit sheet is then prepared showing checks and currency received by each cashier, in triplicate. The original is left at the bank with checks and currency, the duplicate is sent to the City

Treasurer, together with the bank acknowledgment of the deposit, while the triplicate is retained by the head cashier.

After the cashiers' totals have been proved, the stubs are passed to the account clerks, by zones. These clerks arrange the stubs in folio numbers and remove the corresponding account stub from the files. In the event of an over- or under-payment, the amount is credited to the account stub, which stub is placed back in the file and a memorandum of the amount credited is placed among these stubs which have been removed, to be used later for balancing purposes. When all stubs, representing payments by cashiers' stubs, have been removed, an adding machine total is taken of the amounts, and the amount tied with the distribution clerk's total for the zone. When this balance has been proved, the accounting stubs are then stamped with the date of payment and filed in the paid or closed section of the cabinet.

At the expiration of the date of payment, approximately 85 or 90 percent of the accounting stubs comprising the unit have been removed, balanced, and filed in the paid file. The remaining 15 or 10 percent represent unpaid accounts. On these records the delinquent notice is removed and completed with the necessary information, and these notices are mailed in window envelopes, the reason for this being that it is against the postal regulations to mail dunning notices on post cards.

At the expiration of the second payment date, a bill is prepared in triplicate. This is a fanfold bill, of which three copies are prepared, the original serving as a cashiers' guide, the duplicate as a turn-off foreman's record, and the triplicate as the turnkey's, or collector's, bill. On all of these accounts a penalty is set up, of $1.00 or $1.50, for city and county accounts, respectively, and a blanket charge for this amount is sent the general bookkeeper to be set up against that billing unit.

Payments returned by turnkeys are handled as regular collections. Failure to receive remittance ordinarily results in the shutting off of water service, but in these times discretion is used to the extent of granting extensions of time of payment for worthy accounts.

Adjustments of customers' accounts are provided for through the issuance of credit memorandum forms in duplicate, of which the original is sent to the general bookkeeper and the duplicate to the account clerk for the posting of the accounting stub.

In Ohio cities water rents are assessed against the property, and in

accepting an application for water service, this application is checked against the accounting file, and and if there is no accounting stub in the unpaid file, the account is O. K. for service. This is done with the assurance that all accounts had been paid to that date. If there is an unpaid account, it is necessary that the owner or new consumer pay the delinquent bill before services will be reëstablished. These applications for either the turning on or shutting off of water are taken in person, by telephone, or by mail, as the customer's signature is not essential, and are written on an automatic register, which contains six copies of fanfold forms. The original is filed numerically in a permanent binder and gives a complete sequence of all orders; the duplicate is sent to the turnkey foreman; the triplicate is sent to the turnkey foreman and turned over by him to the turnkey; the quadruplicate is used in the office as a check copy; the fifth copy is sent to the Addressograph division, and the sixth copy to the Meter division. Upon the turning on or off of the water by the turnkey, the date and the meter reading are entered on his copy, which is passed to the foreman, who removes his copy from a pending file and returns the turnkey's copy to the office. Here the office checking copy is removed from the pending file, and the information necessary for the establishment of the initial or final billing of an account is noted and copied from the office copy to the meter sheet, after which the account is billed.

In the Cincinnati area there are approximately 90,000 consumers. A schedule has been arranged so that approximately 10,000 accounts are billed quarterly every ten days. Bills are rendered on the 5th, 15th and 25th, and are payable on the 15th, 25th and 5th, respectively. Three accounting clerks handle these 90,000 accounts by the establishment of recurring billing periods. Prior to the mailing of the ensuing bill for the unit, each account clerk balances with the general bookkeeper in detail. The outstanding feature of this arrangement is the setting up of all charges, and the crediting of all cash receipts and allowances by the general bookkeeper, thus establishing absolute control and the proving of these totals by the individual account clerks.

The stub plan of accounting offers the following advantages: elimination of all "paid" or closed accounts; an absolute proof of crediting all payments; corresponding reduction in the number of accounts to be handled in following up unpaid accounts; absolute assurance of balance at close of billing period through proof of posting credits; minimum of effort in preparation of delinquent notices and turn-off bills, and in carrying forward unpaid balances to new bills.

The stub plan affords a greater flexibility for the application of mechanical billing equipment than any other method, and has been proved to be the best means of expediting the preparation of bills and accounting for customers revenues. In Water Works billing, particularly, is it indispensable, since the meter books, previously described, carry a complete record of the consumer's account, and it has been necessary to refer to the account stub only to determine the date of payment.

Other innovations provided by the stub plan cover service branch applications, meter service applications, and special sales of water, usually consisting of water used for construction purposes. It has also been adapted to the billing of meter repairs, and an absolute control of all those units is placed with the general bookkeeper. The multiplicity of operations through highly specialized units prevent any possible collusion in mishandling accounts, and since each unit must balance individually and collectively, it has been proved that the stub plan of accounting is the most practical for the frequent billing of a large number of consumers.

In conclusion, I do not feel that it is fair for me to credit the reduction in cost of operation in Cincinnati, where the ledger plan, with monthly billing, had been in effect, to the stub plan of accounting, as the greater part of this saving has been due primarily to the change to quarterly billing. Incidentally, this curtailment of expense in the Commercial Division amounts to approximately $100,000.00 per year and was instrumental in bringing about a substantial reduction in water rates. It is fair, however, to state that the procedure which has been installed, together with the mechanical equipment in operation, provides for a minimum of personnel, a practical flexible working schedule, rendition of neat, accurate bills, the establishment of absolute controls, and has promoted a spirit of coöperation which has placed the Commercial Division in a very favorable light, so far as public relations are concerned.

DISCUSSION

Mr. Maloney (Pittsburgh, Pa.): Mr. Hoffman spoke about the post card plan and I inferred from his statement that it had more than a post card attached. In other words, do you have more than a regular post card and afterwards detach them?

Mr. Hoffman: Our bills are printed on government post card stock. They are 15 inches long. The accounting stub is $5\frac{1}{4}$ inches, and the delinquent is $4\frac{1}{4}$ inches. We sever the delinquent part at once, so that the remaining one is $10\frac{1}{2}$ inches long. We cut the office record from the bill, leaving the standard government post card bill $5\frac{1}{4}$ inches long. We use a postage meter machine. We get the time of mailing.

Mr. Maloney: You spoke about your breakdown on your analysis sheet—your data sheet. Do you carry your account number?

Mr. Hoffman: We have 35 accounts to the sheet, folio 1–35 or 100–135 inclusive. We do not number each individual item, due to the fact that the sequence of the billing will locate it. After the billing has been completed, we check the bill with the meter sheet to see that the proper billing was put on the right account. We only use the data sheet to recapitulate and compile our revenue.

Mr. Maloney: Do you make a recapitulation of the consumption in blocks?

Mr. Hoffman: No, not at that time.

Mr. Maloney: Do you show the consumption of water through the various types of meters?

Mr. Hoffman: We do not at that time. We make an analysis of our revenues by sizes of meters and by certain consumers in quantities. We do that about a month later, after the close of the collection period.

Mr. Maloney: What do you do with regard to registration of your meters? In other words, when you put a meter in for your consumer, you naturally use 30 gallons for test, do you turn that back or do you start from that point?

Mr. Hoffman: We always set it back to 15. We find that it takes 15 cubic feet to test the meter.

Mr. Maloney: When you take it from one customer to another, do you always set that back to 15?

Mr. Hoffman: Yes, we set it back each time.

Mr. Maloney: How about the favoritism shown by readers? With regard to new consumer, do you let the old meter stay in the house?

Mr. Hoffman: We never move the meter. When a consumer makes application for a new service branch, that application must be accompanied by a meter application, which is given a serial number. It is tested at the meter repair shop. It is given a tag with that number on, and it is always known as that number, with that address. In years to come, when it is necessary to replace by new meter, we keep account of that, giving the meter installed a new number.

Mr. Cogan (Charleston, W. Va.): I am sorry to say that I did not hear your entire paper, Mr. Hoffman, but I gathered that there was considerable saving in changing from the monthly to quarterly billing. Have you had any complaints due to leaks and necessary adjustment, perhaps due to leaks, on account of this quarterly billing?

Mr. Hoffman: I did not want to go too much into detail, but I am glad you brought that out. Cincinnati is peculiarly situated topographically. The city proper is situated in a basin surrounded by hills. That basin is the oldest part of the city. Twenty percent of the consumers are in that basin and they are responsible for 80 percent of our troubles. With up-to-date suburban plumbing, there is very little trouble. We read and bill, monthly, meters over 2 inches in size. Two percent of our accounts, billed monthly, bring us in 50 percent of our revenue, so we have a uniform flow of revenue.

Chairman: Did I understand you to say that in the State of Ohio the law permits the property owner to own the meter himself?

Mr. Hoffman: He must pay for the installation and buys the meter. Naturally he owns the meter.

Chairman: He buys it from the Department?

Mr. Hoffman: We have just entered into an arrangement by which we are buying a large number of meters, and we pass them on

to plumbers and consumers at cost. This has many advantages. One is that the consumer is able to get new meters cheaper than the cost of having the old ones repaired.

CHAIRMAN: How about the overhead?

MR. HOFFMAN: We have a price f. o. b. Cincinnati. The consumer calls at our meter repair department, picks up the meter and, outside of the clerical effort involved, which we would have whether he bought the meter from us or not, there is no overhead involved.

MR. MALONEY: Do you classify the city into certain districts?

MR. HOFFMAN: We have the city divided into nine zones. Some areas cover much more ground than others, but the original arrangement was to provide for a uniform number of meter readings to give us our basic work schedule which followed after the meter reader.

MR. COGAN: Suppose a consumer desires his meter tested. Does the Department test it for him, and is there a charge or not?

MR. HOFFMAN: We make charges sometimes. If a consumer gets what according to his meter record appears to be a regular bill, he is charged for the testing, but if we order it out at our discretion there is no charge for testing.

CHAIRMAN: Do you take the meters out on those large bills to test them?

MR. HOFFMAN: No, when our meter readers notice any unusual difference between the meter readings they take note of it and make and inspection. Then that inspection is checked back at the office of the Department. In other words, if any meter readings are reported at the office that are out of line with the usual consumption, we mail them a post card notifying them of the fact.

The State law of Ohio provides that no adjustments be made on water leakages, but we have had a peculiar situation here. On those accounts that we read monthly and bill quarterly, under no circumstances are any adjustments made. A quarterly-billed consumer should be entitled to the adjustment, on the theory that if he had had

his meter read monthly it would have been noticed at the end of a month without waiting until three months.

A MEMBER: How do you get by the State Examiner on that, giving rebates?

MR. HOFFMAN: The State Examiner holds to the ruling of the Attorney General in 1918 on the question of leakages.

MR. MALONEY: You say that the State Law says that the consumer owns the meters?

MR. HOFFMAN: I mean that the consumer buys the meter when it is put into service and he must pay for the maintenance of that meter. He owns the meter.

MR. MALONEY: You said that the law said that the customer had to own the meter.

MR. HOFFMAN: No; here's what I mean. When anyone makes application for a service, the plumber for the owner or the owner for a tenant, they buy the meter and have that meter installed. We are 100 percent metered here in Cincinnati.

A MEMBER: In Cincinnati, does the property owner assume liability for the payment of water charges?

MR. HOFFMAN: Our charges are against the property and an old bill must be paid by an applicant for a new installation, or by the owner.

MR. BANKSON: Do you check up the losses between the pumps and the meters and what the result might be?

MR. HOFFMAN: Primarily the consumption was taken off to check with the revenue and again with seasonal consumption for those districts. Unfortunately, in zoning Cincinnati, we did not lay out our districts in the distribution unit. The perfect method is to get districts in the same areas as that supplied by the distribution system. Then the consumption for certain districts is comparable with the

pumpage. It is our plan to tie in the consumption that is billed with that of the pumpage as reported by the city. We can only get that as a whole at the present time, but if that were broken down in geographical divisions it would be very practical.

MR. MALONEY: Do you check the previous registration with the next registration?

MR. HOFFMAN: The meter reader does that.

MR. MALONEY: I mean in totals.

MR. HOFFMAN: No. We are using at the present time "Burroughs Public Utilities Billing Machines" for accumulating totals.

CHAIRMAN: Mr. Maloney, you want a check on the total meter readings that would balance the water billing.

MR. MALONEY: It is an audit of your total readings.

MR. BANKSON: Do I understand that you are reading continuously?

MR. HOFFMAN: We have a schedule. Three months to a day practically intervenes between billings. In the downtown district we read monthly. We are enabled to get 10,000 bills out every ten days. Therefore the bills go out continously rather than holding them to the first of the month. Rather than bill very day, we bill 10,000 every ten days.

A GRANULOMETRIC TEST FOR SAND

By Christien M. Wichers[1] and E. Jacobs[2]

The *best* known method of grading sands for filtration purposes is the determination of the "Effective Size" (E. S.) and the "Uniformity Coefficient" (U. C.) of a given sample.

The *effective size* of the sample of sand is that diameter (as indicated by the mesh of the sieve employed) such that 10 per cent by weight of the material is of smaller size, and 90 percent, therefore, of larger grains. The specification of such surprising figures is based on the belief that the 10 percent of fine sand has as much influence in the filter-bed as the 90 percent of coarser grains. If, when passing the sample of sand through the standard set of seven graded sieves, no one sieve indicates the exact 10 percent, the equivalent size of mesh must be estimated by interpolation.

The *unformity coefficient* is the ratio between the number of the above sieve (that is, the side of the square forming the mesh) separating the coarser 90 percent from the finer 10 percent on the one hand, and the number of the sieve which retains 40 percent coarser sand, while passing 60 percent finer grains, on the other hand.

It would seem that this system of grading arose from the endeavor to standardize sand by means of two more or less distinctive figures associated with the sieve numbers concerned; but the description thus indexed appears insufficient for the guidance of persons interested in filtration. However useful for general specification, the common method of granulometric analysis provides but an incomplete indication of the physical character of the sand; so that efforts have been made from time to time to devise a more satisfactory system of testing.

The writers accordingly submit what they believe to be a superior system, based on two most pertinent factors in the process of filtration, namely: (*a*) *the surface area of the grains per unit volume of compact sand*; and (*b*) *the volume of the voids or interstices per grain of compact sand.*

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Although the precise rôle in the process of filtration played by each physical, chemical and biological action may not be fully understood, it can yet be confidently assumed that the extent of surface area presented by the granules is an important factor bearing upon these actions. Moreover—what is of significance in the same connection—the surface area of the grains affords some indication of the number of points of contact between the granules; while the average radius of curvature of the grains, which probably has some influence upon physical effects, is roughly indicated by the same superficial area.

The total interstitial space per unit volume of the medium is not of primary importance in filtration considerations; and indeed the figure does not vary much for certain different sorts of sand.

Of more significance are the actual dimensions of the voids as represented by the estimated interstitial space per grain of sand, for with this coefficient is associated the degree of contact between the water to be purified and the active agencies—physical, chemical or biological—which effect the purification.

(It must not be concluded from this consideration that, for the most efficient filtration, the smallest ratio of void-space to number of grains should be sought; for the accumulation of slime between the granules creates a limiting factor; and as this accumulation is dependent upon the character of the water to be dealt with, the type and the construction of the filter, and the rate of filtration, these items will influence the choice of the sand to be used).

Proceeding to detail, we may say that in the testing of filter sand the following two points are of fundamental importance:

(*a*) The total surface area of the grains expressed in sq. cm. per cc. of compact sand = S sq. cm. per cu. cm.

(*b*) The volume of the void-space between the grains, expressed in cu. mm. of void per 1,000 grains = V, cu. mm. per 1,000 grains. We discuss these coefficients S and V in detail, as follows.

THE COEFFICIENT S

In the sand-bed of both rapid and slow filters biological activities play a prominent part in the process of purification. The organisms, thus engaged, reside in the sand-bed, and since they to some extent attach themselves to the grains, the *total surface area* of these granules becomes of direct importance.

Further, since the organisms also hang in webs or films between

the neighboring grains, the *number of points of contact* between the grains assumes no small significance, and this number is definitely related to the *total surface area*.

Again, since surface tensions also play a part in purification, the *radius of curvature* of the surface of a grain enters into consideration; and this radius, too, is related to the surface area of the grain it being understood that in theoretical discussion we assume the grains to be spherical.

If, for instance, we assume the grains to be of equal size, then, as the number of grains to the litre is imagined to increase by diminishing the size of the granules, and that in such a way that the total surface area increases as the first power of some variable x, then the number of points of contact increases as the cube of x, while the radius of curvature diminishes with the first power of x.

In sand with granules of different sizes, the situation is, of course, more complex, but the thesis remains that in increasing the total surface of the sand, the number of points of contact is increased, and the radius of curvature is diminished.

We may thus reasonably assume that the filtration value of sand and the efficiency of back wash have a close relation to the total surface area of the grains, it being understood that the requirements of filtration and of back wash are contradictory to some degree, so that practical limits can be deduced from well-tried sands for each purpose.

THE COEFFICIENT V

The total volume of the voids in the sand (per litre of compact sand) is not of great significance, and does not vary much for different samples of filter sand; but the actual size of any void is of considerable importance, since in such a void the biological actions proceed. The smaller, on the average, the voids, the more intimately is the percolating water brought into contact with the organisms. Moreover, the smaller the voids, the more efficient is the mechanical filtration. On the contrary, with mechanical filters the back wash will be most efficient in sand with large interstices per grain, and also formation of mud balls will more easily be avoided.

We may thus assume that the filtration value of sand is increased according as the total interstitial space is more finely distributed. In other words, according as the void-space per grain is diminished and that the requirements of cleansing are contradictory; so here

again are limits, which qualify each particular case. These limits can be estimated from actual experience.

It will have been remarked that the volume of the sand is given when "compact;" and the reason is this: both *S* and *V* must be specified relative to the sand as it lies in the filter. For testing purposes, a similar condition is created by pouring the dry sand slowly into a vessel of water, meanwhile tapping or shaking the vessel thoroughly.

SIMPLIFYING ASSUMPTIONS

In determining the coefficients *S* and *V* for a sample of sand, we assume (as already mentioned) that the grains are spherical. Moreover, we assume that for any residue-portion of sand which has passed through a sieve *C*, but is caught on a sieve *D*, the average diameter of the grains is the semi-sum of the mesh-widths of the two respective sieves. We take the true density of the sand (solid) as 2.6 kilograms per litre. We, in Holland, employ the metric system of units, but English or American measures may, of course, be followed.

APPARATUS

The necessary equipment consists of a set of sieves, duly stamped, together with apparatus for determining directly the total volume of the voids in 1 litre of compact sand. For the former, we use a set of sieves, 15 cm. in diameter, the copper gauze of which having mesh-widths (in mm.): 6, 4, 2, 0.5, 0.4, 0.3, 0.2, 0.1. Other standards, such as the American, may be employed at will.

For the determination of the voids, we employ Bach's apparatus, involving a special flask of one liter capacity, as shown in Figure 1, from which the action is clear. While the water is slowly introduced from below, the sand (previously dried and weighed) is allowed to flow together, the apparatus being meanwhile continually tapped, so that the granules assume the closest degree of contact. This operation occupies from half an hour to three quarters. The apparatus is so calibrated that the volume of void-space, in cc. per litre, can then be read off directly.

METHOD OF PROCEDURE

The sand to be tested is dried at 100°C. and 500 grams of the dried and cooled sand are weighed out and passed through the set of

Bind in

ERRATA

Vol. 24, No. 5, May

Pages 709, 710 and 712; W_1, W_2, W_3, etc. should be w_1, w_2, w_3, etc.

Page 710, last two lines; omit the word "area" after "volume" and after "weight." Insert the symbol π in numerator of equation in last line.

Page 711, second line; place ÷ symbol in place of : immediately after grams. Fourth line; place = immediately after d^2.

Page 712; $(S_1 + S_2 + \cdots S_3)$ should be $(s_1 + s_2 + \cdots s_3)$

Second tabulation, denomintaor of "105" should be 10^5.

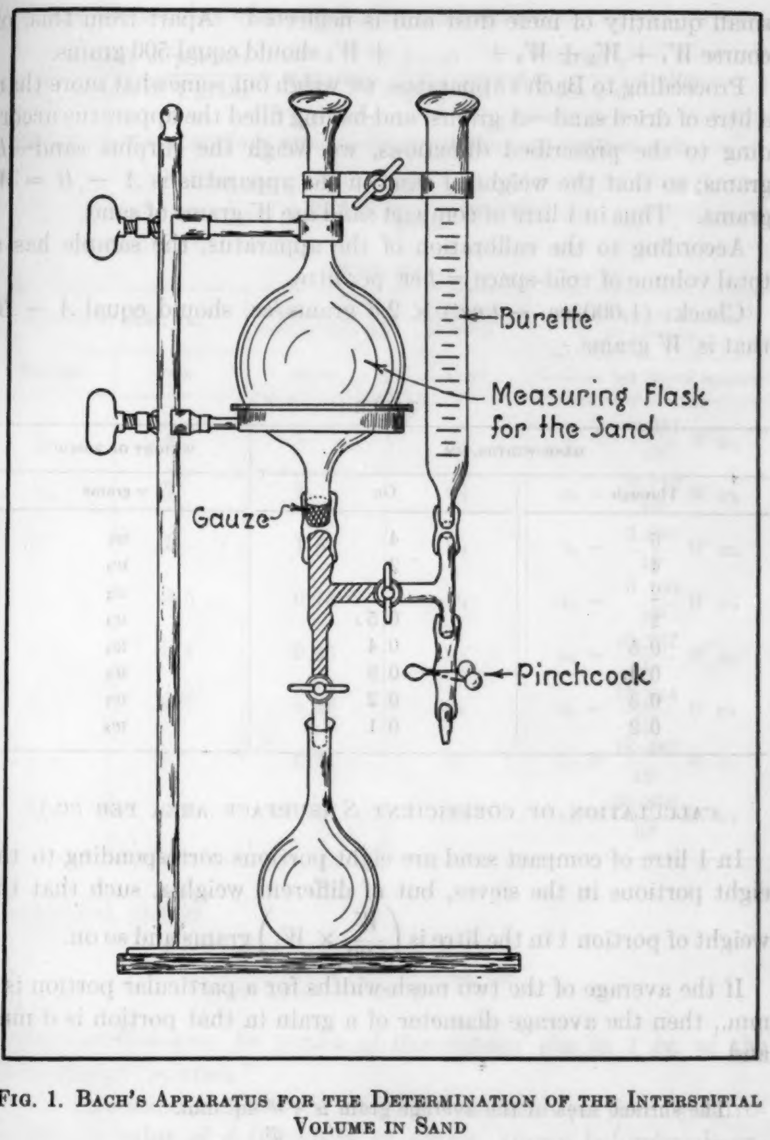

FIG. 1. BACH'S APPARATUS FOR THE DETERMINATION OF THE INTERSTITIAL VOLUME IN SAND

sieves. This provides us with eight "portions," of weights W_1, W_2, etc., as indicated in table 1.

The sand which passes through the last (0.1 mm.) sieve is but a

small quantity of mere dust and is neglected. Apart from this, of course $W_1 + W_2 + W_3 + \ldots\ldots + W_8$ should equal 500 grams.

Proceeding to Bach's apparatus, we weigh out somewhat more than a litre of dried sand—A grams; and having filled the apparatus according to the prescribed directions, we weigh the surplus sand—B grams; so that the weight of sand in the apparatus is $A - B = W$ grams. Thus in 1 litre of compact sand are W grams of sand.

According to the calibration of the apparatus, the sample has a total volume of void-space = t cc. per litre.

Check: (1,000 cc. $- t$ cc.) $\times$ 2.6 grams/cc. should equal $A - B$, that is, W grams.

TABLE 1

Mesh-widths, mm.		Weight of residue
Through	On	w grams
6	4	w_1
4	2	w_2
2	1	w_3
1	0.5	w_4
0.5	0.4	w_5
0.4	0.3	w_6
0.3	0.2	w_7
0.2	0.1	w_8

CALCULATION OF COEFFICIENT S (SURFACE AREA PER CC.)

In 1 litre of compact sand are eight portions corresponding to the eight portions in the sieves, but of different weights, such that the weight of portion 1 in the litre is $\left(\frac{W}{500} \times W_1\right)$ grams and so on.

If the average of the two mesh-widths for a particular portion is d mm., then the average diameter of a grain in that portion is d mm. and

The surface area of the average grain is $\pi\ d^2$ sq. mm.

The volume area of the average grain is $\pi\ \frac{d^3}{6}$ cu. mm.

The weight area of the average grain is $\pi\ \frac{d^3}{6}$ cu. mm. $\times$ 2.6 mgm./cu. mm. $= \frac{2.655d^3}{6,000}$ grams

Hence the number of grains in this portion is

$$\frac{\text{weight of portion}}{\text{weight of 1 grain}} = w \text{ grams} : \frac{2.6\ \pi\ d^3}{6,000} \text{ grams} = \frac{6,000\ w}{2.6\ \pi\ d^3} \text{ grains}$$

Again the total surface area of the grains in any portion w is

$$\frac{6,000\ w}{2.6\ \pi\ d^3} \times \pi\ d^2\ \frac{6,000\ w}{2.6\ d} \text{ sq. mm.}$$

TABLE 2

WIDTHS OF MESH, MM.		AVERAGE DIAMETER OF GRAINS	WEIGHT OF PORTION	GRAIN-SURFACE-AREA OF PORTION
Through	On	d mm.	w grams	s sq. cm. per litre of mixture
6	4	5	w_1	$s_1 = \frac{0.924}{10^5} W w_1$
4	2	3	w_2	$s_2 = \frac{1.540}{10^5} W w_2$
2	1	1.5	w_3	$s_3 = \frac{3.080}{10^5} W w_3$
1	0.5	0.75	w_4	$s_4 = \frac{6.160}{10^5} W w_4$
0.5	0.4	0.45	w_5	$s_5 = \frac{10.267}{10^5} W w_5$
0.4	0.3	0.35	w_6	$s_6 = \frac{12.914}{10^5} W w_6$
0.3	0.2	0.25	w_7	$s_7 = \frac{18.480}{10^5} W w_7$
0.2	0.1	0.15	w_8	$s_8 = \frac{30.800}{10^5} W w_8$

Rearranged, this is

$$\frac{12\ W\ w}{10^5\ 2.6\ d} = \frac{4.62\ W\ w}{10^5\ d} \text{ sq. cm.}$$

of grain-surface-area *for grains of this average size* in 1 cc. of the *given compact "mixture."*

This expression can now be simplified for each portion by introducing the value of d (which is, of course, known beforehand) expressed as the semi-sum of the two corresponding sieve-mesh widths; and so eight coefficients—which will never vary for a given set of sieves—are obtained once and for all. These constants are set out for our own sieves in table 2.

As previously stated, W (in the last column) is the weight in grams of the litre of compact sand *in Bach's apparatus;* and $W_1, W_2 \ldots\ldots W_8$ are the weights in grams of the eight residue-portions of the 500 grams of dry sand passed through the sieves.

Now, to obtain our coefficient S (the total surface area of all sizes of grains per cc. of compact mixture) we have merely to add up the eight quantities ($S_1 + S_2 + \ldots\ldots + S_8$) in the last column, these having been calculated from the determined weights.

Example: For a particular sample we have:

Bach's apparatus: $W = 1768$ grams; $t = 320$ cc.

Set of sieves:

w_1	5 grams
w_2	30
w_3	165
w_4	115
w_5	140
w_6	30
w_7	10
w_8	5
	500 grams

Calculation:

$$s_1 = \frac{0.924}{10^5} \times 1{,}768 \times 5 = 0.08$$

s_2	0.82
s_3	8.98
s_4	12.52
s_5	25.41
s_6	6.84
s_7	3.26
s_8	2.72
S =	61 sq. cm. per cc.

CALCULATION OF COEFFICIENT V (VOLUME OF VOID-SPACE PER THOUSAND GRAINS)

From Bach's apparatus we get that the total volume of the void-space in 1 litre of compact sand is t cc.

It has been previously established that the estimated number of grains in any sieve-portion

$$w \text{ is } \frac{6{,}000\ w}{2.6\ \pi\ d^3}$$

so that the number of grains of the corresponding approximate size in the corresponding portion in 1 litre of compact sand in Bach's apparatus is

$$\frac{W}{500} \times \frac{6{,}000\, w}{2.6\, \pi\, d^3} \text{ (grains of sand)}$$

As with S, this expression can be simplified to form a constant coefficient for each sieve-portion by substituting for d the semi-sum of the two corresponding mesh-widths. We thus arrive at the set of expressions *for a given set of sieves*, to be employed at all times, as shown in table 3.

TABLE 3

WIDTH OF MESH, MM.		AVERAGE DIAMETER OF GRAINS	WEIGHT OF PORTION	NUMBER OF GRAINS IN PORTION (BACH)
Through	On	d mm.	w grams	n
6	4	5	w_1	$n_1 = 0.01\, W\, w_1$
4	2	3	w_2	$n_2 = 0.05\, W\, w_2$
2	1	1.5	w_3	$n_3 = 0.44\, W\, w_3$
1	0.5	0.75	w_4	$n_4 = 3.48\, W\, w_4$
0.5	0.4	0.45	w_5	$n_5 = 16.15\, W\, w_5$
0.4	0.3	0.35	w_6	$n_6 = 34.27\, W\, w_6$
0.3	0.2	0.25	w_7	$n_7 = 94.23\, W\, w_7$
0.2	0.1	0.15	w_8	$n_8 = 434.91\, W\, w_8$

Total number of grains in 1 litre of compact sand $= \Sigma n =$ sum of above expressions.

We thus estimate the number of grains in 1 litre of compact sand; and having already measured the volume of the void-space (t cc.) in the litre by means of Bach's apparatus, we can easily deduce the volume of void-space per thousand grains.

Thus

$$1{,}000\; t \text{ cu. mm. of void-space corresponds to } \Sigma n \text{ grains}$$

$$\frac{1{,}000}{\dfrac{\Sigma n}{1{,}000}}\; t \text{ cu. mm. of void-space corresponds to } 1{,}000 \text{ grains}$$

i.e. $\dfrac{10^6\, t}{\Sigma n}$ cu. mm. per thousand grains; and this is the desired coefficient V.

Example. As before,

$$W = 1{,}768 \text{ grams and } t = 320 \text{ cc.}$$
$$w_1 = 5 \text{ grams}, w_2 = 30 \text{ grams, etc.}$$

Then:

$$n_1 = 0.01 \times 1{,}768 \times 5 = 884$$

n_2	2,652
n_3	128,357
n_4	707,554
n_5	3,997,448
n_6	1,819,272
n_7	1,665,986
n_8	3,844,604
n	12,167,000

Whence:

$$V = \frac{10^6 \times 320}{12{,}167{,}000} = 26 \text{ cu.mm. of void-space per thousand grains}$$

REMARKS

It will be observed from the foregoing discussion that the average weight of the grains in any sieve-portion has been estimated by assuming these to be spherical, of diameter equal to the semi-sum of the two corresponding mesh-widths, and taking the real specific gravity of the sand as 2.6. With a view to checking the accuracy of this supposition, the writers went to the trouble of counting for several kinds of sand a large number of grains, taken from each particular sieve-portion, and directly weighing the collection, so determining the average weight more directly. The results were sufficiently confirmatory to warrant the adoption of the first assumption for common technical purposes.

COMPARISON OF THE NEW COEFFICIENTS WITH THE OLD COEFFICIENTS

When the recommended criteria are applied to different samples of sand, it is found that for distinctly different samples of material, the coefficients S and V show correspondingly marked variation, while with nearly similar grades these figures are accordingly steady. When, however, the corresponding values of the old coefficients ("effective size" and "uniformity coefficient") are determined for such samples, it is found that the variation in the new coefficients does not "keep step" with variation in the old.

We submit that the old coefficients—effective size and uniformity coefficient—provide but a defective description of the sample, while the recommended criteria, *embracing more adequately the various sizes of grain and comprehending two factors of fundamental moment in filtration and back wash practice* deserve the attention of the technical authorities interested.

The writers' thanks are extended to J. J. Elliott, Lecturer in Sanitary Science at the Huddersfield Technical College, for assistance in preparing this paper for the press.

THE NEW IRON REMOVAL PLANT AT WARRENTON, N. C.[1]

By M. F. Trice[2]

The first public water system for the town of Warrenton, North Carolina, was constructed during the winter of 1915–16, to serve a population of 900 people, with one deep well serving as the source of supply. Work on the distribution system was begun in October and the completed project turned over to the city the following April.

The original well is 500 feet deep and is located at the northern edge of town. The pumping equipment consists of one Luitweiler deep well pump having pistons 150 feet deep which deliver 100 gallons per minute. The pump is equipped with one 20 H. P. Allis Chalmers motor. The original system did not include a reservoir at the source of supply, but an elevated steel tank of 60,000 gallons capacity was part of the distribution system. A wooden structure was built over the well site to house the pumping equipment.

In 1921 another well 550 feet deep was sunk south of the town, and at least 1½ miles from the first one. The equipment installed at the second well is identical in every respect with that in use at the original well.

The records of the State Board of Health during the past several years in regard to the Warrenton water all indicate that it has been very unsatisfactory, probably from the first. The character of the water was no doubt responsible for the sinking of the second well in 1921, which is regarded as an attempt to obtain a more palatable supply. The water served consumers occasionally had a distinct color, was always hard, always had a disagreeable taste, and always contained a high content of iron which stained plumbing fixtures and precipitated in vessels upon standing. The city has no industries that depend upon a good quality of water, and the people for the most part relied upon shallow wells and springs for their drinking supply, considering the town water fit only for sanitary and miscellaneous house-

[1] Presented before the North Carolina Section meeting, November 3. 1931.

[2] Assistant Engineer, State Board of Health, Raleigh, N. C.

hold purposes. One enterprizing citizen who ran the local hotel attempted to capitalize the situation by attributing health restoring qualities to the town water and advertised the community as a resort.

Finally, a growing intolerance on the part of the citizens to the continued use of the town supply resulted in a movement for a better municipal water. This agitation culminated in a study of ways and means of improving the situation. After considering surface supplies and abandoning the possibilities as being too expensive, an iron removal plant was decided upon and constructed at the site of the original well.

Since the installation of the system in 1915–16 the town has grown so that the new plant serves a population of 1000 people.

THE IRON REMOVAL PLANT

The iron removal plant consists of the following units which are presented in the order of their position in the scheme of treatment. The first is a coke aerator, followed by a sedimentation basin, which is in turn followed by a pressure filter. The sedimentation basin is partitioned off to form a mixing chamber at the influent end and a so-called "clear well" at the effluent end.

Aerator

The aerator consists of a steel shell 10 feet high and 7 feet wide which is divided into two sections by a ventilating opening around which there is placed a splash apron. Two perforated steel plates of number 8 galvanized metal support beds of selected metallurgical coke, one of which is 4 feet deep and the other 3 feet. The inlet consists of head box and a distribution system which is made up of one central trough and several lateral ones. The capacity of the aerator is 125 g.p.m. The discharge emerging through the lower bed of coke falls about three feet into a concrete pan, the effluent from which flows into the mixing chamber.

Mixing and settling basins

The mixing chamber and settling basins are all included in one rectangular concrete structure, 27 feet 6 inches long, 19 feet 6 inches wide, and 8 feet 6 inches deep, inside dimensions. In the end of the basin adjacent to the aerator a mixing chamber 6 feet 6 inches by 6 feet 6 inches has been formed by the construction of concrete partitions. The wall of this chamber that parallels the end of the basin

is then extended on across to the other side to form the clear well. The remainder of the basin constitutes the sedimentation compartment which has been divided by a middle wall into two sections, or passes. The water passes from the first basin to the second via a weir trough. Thus, influent and effluent are at the same end of the basin, which allows all equipment to be housed in one superstructure. The floor of the latter is formed by a concrete cover over both mixing chamber, clear well, and a portion of the sedimentation basin.

Mixing chamber

The mixing chamber is equipped with an agitator that consists of a central vertical shaft from which paddle arms extend in several planes. Wooden stator blades built out from the sides of the chamber are so spaced that the paddles pass between them. The agitator is equipped with one 2 H.P. motor for 220 volt, 3 phase, 60 cycle alternating current; push button start and stop is provided with under voltage and overload protection. In addition one Jones oil enclosed reduction gear on common base with the motor is provided. One Wallace and Tiernan Type O motor driven dry chemical feeder is used for the addition of lime hydrate to the mixing chamber. The capacity of this machine varies from 0.1 to 36 pounds per hour. The mixing chamber provides a 20 minute period of agitation; its capacity is 2700 gallons. The influent to the mixing chamber is through the bottom of a small triangular compartment formed by placing a wooden partition across one corner; diagonally opposite and at the top the water flows through an opening into the sedimentation basin.

Sedimentation basin

In the first pass of the sedimentation basin and located about 2 feet from the mixing chamber, and in the second pass just beyond the weir trough are wooden spreader baffles that extend from above the water to the floor of the basin. Each pass is provided with drains in the bottom for the removal of sludge in cleaning. The inside dimensions of each pass are 20 feet 6 inches long, 9 feet 6 inches wide, and 8 feet 6 inches deep. The effluent from the basin is over a weir wall into the clear well, or settled water storage. At the rate of 125 g.p.m. the sedimentation basin provides a retention of 3.3 hours.

Clear well

The clear well is merely a compartment in which the settled water is stored; it is probably more correctly designated as a large suction

well. It is 12 feet 6 inches by 6 feet 6 inches in plan and 8 feet 6 inches deep, having a capacity of 5200 gallons. This additional storage increases the sedimentation period to 4 hours.

The filter

The filter operates under pressure and is of the vertical type, the shell of which is 96 inches, inside diameter, and 8 feet 3 inches high. The total depth of the filter bed is 42 inches constructed as follows:

	Depth, inches
16.72 cubic feet 1 by ½ inch gravel	4
16.72 cubic feet ½ by ¼ inch gravel	4
25.10 cubic feet ¼ by ⅛ inch gravel	6
41.80 cubic feet coarse sand	10
Effluent size, about 1.0 mm.	
Uniformity, coefficient 1.5 to 1.6	
75.4 cubic feet fine sand	18
Effluent size, 0.4 0.4 to 0.5 mm.	
Uniformity, coefficient 1.5 to 1.6	
	—
Total depth filter bed	42

The rate of filtration is 2½ g.p.m. per square foot of surface sand area, which is a higher rate than is permitted by the State for rapid sand filters, it being 2 g.p.m. per square foot, but since removal of pathogenic bacteria is not the prime function and the turbidity is low, it was allowed. The capacity of the unit is 125 g.p.m. and it is designed for a working pressure of 75 pounds per square inch.

The filter is equipped with one 125 g.p.m. Allis Chalmers Centrifugal Pump operated by a 7½ H. P. motor of the same make.

GENERAL

A brick superstructure 20 feet by 20 feet in plan and 18 feet high houses the filter pumps, dry feed machine, and provides limited storage for lime and space for simple chemical control tests.

During the construction of the plant the well continued to serve the community. Upon completion the iron removal plant was cut in at the well and again at a point about 40 feet away on the line to town. This original main serves as a by-pass in the present set up.

Construction on the new plant was begun in September, 1930, and completed in November, two months being required to complete the job.

COST

Probably the most interesting feature in connection with the erection of this plant is the cost. When the city was faced with the task of improving the quality of the city water, they were also confronted with a period of business depression. The times, therefore, demanded economy and close trading in the expenditure of public funds. That the Town Commissioners were long headed business men possessed of certain scottish traits is evidenced by the costs in table 1.

The only costs that could be added to the above were the services of the superintendent of the local water department who acted as

TABLE 1

Construction:	
Concrete settling basin (contract job)*	$2,700.00
Material and labor on superstructure†	407.51
Equipment:	
Permutit Company (aerator, agitator, filter and appurtenances)	2,825.00
Pipes, valves, etc., not furnished by above	281.31
Allis-Chalmers Pump and motor	285.35
Freight and drayage	414.02
Labor, cost of erection	70.17
Engineering service‡	402.60
Lawyers fee for contract	10.00
Total cost	$7,395.96

* H. E. Browder, Raleigh, N. C.

† Erected under supervision of local superintendent of water works.

‡ W. H. Boyd, resident engineer; Wm. Channon, Permutit Company, erection engineer. Spoon and Lewis, Consulting Engineers, Greensboro, N. C., design of basin.

general foreman in the construction of the work, but whose salary would have gone on as usual, had he not taken it upon himself to help build the new plant.

The project was financed without difficulty and with favorable terms at a local bank.

OPERATION

The original deep well pump delivers the water to a head box at the top of the aerator, which is a part of the manifold-lateral-trough

distributor system. Passing the aerator, lime is added in the mixing chamber and the water settled and finally stored in the settled water compartment. A contrifugal pump then forces the water through the pressure filter and thence directly into the distribution system.

SITUATION PRIOR TO CONSTRUCTION OF PLANT

Some idea of the quality of the water in the distribution system may be had from an analysis of a sample of city water collected two years prior to the construction of the plant; at this time the iron content of the water at a local hotel was 3.34 p.p.m., with 3.04 p.p.m. precipitating out on standing. On another occasion a year later an analysis indicated the following in a sample of city water:

	p.p.m.
Total Fe	4.8
Manganese	0.9
Total hardness ($CaCO_3$)	40.3

These results indicate a very aggressive water, since the iron content of the well water was never found to be greater than 1.0 p.p.m.

PLANT EFFICIENCY

On April 7, 1931, after the plant had been in service for four months, a study of it was made by the State Board of Health. This work consisted primarily in the collection of samples at various points through the plant and their subsequent analysis, both at Warrenton and at the water and sewerage laboratory of the State Health Department in Raleigh. The efficiency of the plant is summarized in the accompanying copy of the mineral analyses of the raw well water and the finished product. It will be observed that the iron is appreciably reduced, the manganese and hydrogen sulphide removed and the lime content and hardness slightly increased, which, of course, is expected. The lime applied at the time the samples were collected amounted to only 3 p.p.m.; this was later increased, to 17 p.p.m.

The effect of the various units on the properties of the water is outlined in table 2.

The aerator removes most of the CO_2; increases the pH; and reduces the iron content. There is a 65 per cent reduction in iron content through the plant.

TABLE 2

Operating efficiency

Results in parts per million

	RAW	AERATED	MIXING CHAMBER	FILTERED WATER
Carbon dioxide	27.0	2.0	0	
Total alkalinity (M. O.)	37.0	37.0	48.0	
Phenol alkalinity	0	0	Trace	
Hydrogen sulphide	0.25	0	0	
pH	6.30	7.7	8.4	
Iron	0.75	0.40		0.26

TABLE 3

Mineral analyses—Warrenton water

Results in parts per million

	RAW	FILTERED
Total volume of sample	3,765 cc.	3,820 cc.
Silica	26.00	29.80
Iron (total)	0.75	0.26
Calcium	8.00	10.90
Magnesium	6.68	5.72
Manganese	0.15	Trace
Sodium, Potassium	20.10	22.1
Carbonate radicle	0	0
Bicarbonate radicle	45.20	50.00
Sulphate radicle	39.20	38.10
Chloride radicle	9.50	9.00
Nitrate radicle	Trace	
Loss on ignition	16.00	18.30
Total dissolved solids at 180°C	84.2	90.50
Total hardness as $CaCO_3$ (calculated)	47.3	50.6
Color		
Turbidity		
Suspended matter		
Alkalinity	37.00	41.00
pH	6.30	8.40
CO_2 (carbon dioxide)	27.00	0
H_2S (hydrogen sulphide)	0.25	0

DISTRIBUTION SYSTEM

Although the citizens of the town were immensely pleased with the quality of the water being delivered to them, an analysis of samples from various points on the distribution system indicated a condition far from satisfactory, as will be osserved from the figures in table 4.

Following the results of this work the lime dosage was increased to 1 grain per gallon and the superintendent instructed to maintain the pH in accordance with the results of the marble test. Samples collected from the distribution system a month later, however, showed very little improvement in iron content. It was concluded, therefore, to inaugurate systematic flushing to remove the deposit formed on

TABLE 4

Samples from the distribution system collected April 7, 1931

Results in parts per million

	IRON	pH	ALKALINITY		DISSOLVED OXYGEN
			Phenol	Total	
City Hall (center town)	0.4	8.6	4	39	8.25
South End	0.8	9.0	11	39	0.75
Drug Store (business district)	0.7	8.6	3	38	7.85
Dr. Macon (½ way well to business district)	0.55	8.4	5	36	9.40
Davis (outskirts)	0.78	8.6	4	36	1.60
Skillman (outskirts)	1.20	8.4	0	40	0

the mains by the untreated water in the years before the new plant was built. This would allow the aerator and filter to ripen and a greater reduction in the iron content of the water at the plant could be expected. In the meantime, by keeping the pH of the finished water slightly above 8.4, the aggressiveness of it toward iron would be overcome and the mains could be flushed clean. Additional studies of the distribution system will be made, therefore, only after sufficient time has elapsed for these changes to take place.

This is the first iron removal plant erected in North Carolina and in spite of what chemical analyses may indicate to the contrary regarding the quality of water being delivered to them, the citizens of Warrenton are highly pleased with the performance to date. Moreover, there is every reason to believe that the water will improve

with the continued operation of the plant so that there is hope of removing the last "Doubting Thomas" from the fold of those who believe in the new project and of its value to the community.

This paper in its present form would have been impossible without the assistance of Harold R. Skillman, Superintendent of the Warrenton Water Company, who furnished construction cost data, collected samples, and secured other valuable information which is included in this report.

VALUE OF WATER WORKS CONVENTIONS TO PLANT OPERATORS[1]

By Jane H. Rider[2]

This is not a subject for a formal paper; rather one should talk about the benefits of technical meetings, giving illustrations of human incidents, anecdotes too personal to perform well on a typed page. John Citizen is too apt to think of a gathering of water works men as just another convention, a place where the boys can forget the daily conventions of home life and have a riotous time for a few days. True the technical sessions of the daylight hours may be leavened by good fellowship after sunset, but how many friendships of worth do you suppose are formed sitting stiffly on the hard chairs of convention halls?

Long years ago I timidly asked permission to leave the state to attend a meeting of the American Public Health Association. Scornfully I was told conventions were of no benefit to men and somewhat less than that to women. I muttered something about scientific papers and information our department needed. The only answer was that any papers of value would be printed and could be read in my office with more intelligent understanding than if I listened to them in a crowded hall. All of which is correct, except that it does not take into consideration the personal element of such meetings. Using annual leave and a sketchy bank balance, I went to this meeting on my own, and that investment in travel expense has never passed any of the dividends, as have more highly recommended securities. A few acquaintances made at that time are now friends of long standing, who have more than once helped us with knotty problems.

Now the question of listening to technical papers, some read with fire and rapidity, others droned throughout. The man in the audience may miss a few of the fine points and have only a vague idea of the masses of figures presented; still they will get enough of the writer's meaning to either agree or disagree with him. Disagreeing with the speaker breeds the best sort of extra session discussion.

[1] Presented before the California Section meeting, October 29, 1931.

[2] Director, State Laboratory, Tucson Ariz.

The talk up in someone's room starts out with how wrong that chap was in his figures on water consumption and then jumps to this and that until you have told all your pet experiences and learned from the fellow up state just the things you wanted to know to make your water service run more smoothly.

Recently in the *Engineering News-Record* an editorial comment on the meeting to commemorate the fiftieth anniversary of the founding of the New England Water Works Association was headed: "To Exchange Idea." Certainly that is the essence of all meetings of water works men. How much progress do you think would be made in the smaller towns, if the plant operators did not know any of the other men in their profession? How many of them would read technical publications for the information they contained, if there was not some chance to talk over these new facts with some fellow workers? And again, how often are articles read because the author is known and remembered by some incident.

The scientific papers that one hears are important creators of ideas. To read them in cold print is helpful, but how vastly more valuable to be able to discuss them while the subject is still warm; to be able to tell your experience with that phase of operation, or to ask the writer a question that has been bothering you for months. So ideas are exchanged and progress made; old problems have been solved, new methods are being devised. A glance over the programs of a few years ago will indicate the advance. Then we listened to papers on "What is the Legitimate Use of Water" and talked excitedly of the application of colloid chemistry to filter effluents; now there are activated carbons and chloranines.

These are benefits of hearing and discussing papers; probably preparing them is of even more value to the water works operator. It is no secret that a man is more concerned with his plant if he feels that the methods he develops are of interest to some one else. How much more carefully and willingly records are kept, if they are to be used as the basis of study, and the results are to be read with the operator's conclusion at a meeting of his section. Such efforts engender an honorable professional esteem, a pride in good workmanship. There is something very satisfactory in seeing one's name and thoughts in print, and how can most of us achieve this unless we take an active part in our professional societies. To work, to record, to publish conclusions, is infinitely better than just to work twelve months for so much per annum.

Short schools of instruction for operators are held in connection with some of the water works conventions. These give concentrated courses in bacteriological and chemical methods enabling a man to make his own control tests and to interpret results more surely; illustrate new developments of water purification, better operating procedures, and short cuts that have been devised. A bacteriological report will certainly have more meaning for the man who has actually handled test tubes and met the B. coli group face to face. And they will not imitate the pumper in an isolated mining camp who, after being told B. coli indicated sewage contamination of fecal origin, wrote: "You all are sure a bum lot of guessers; the nearest sewer is thirty miles away."

The man attending a section or a national meeting may get to know his fellow workers, may establish better relations with state control officials and the research staffs of the universities, may meet consulting engineers and the sales representative of the manufacturers of water works equipment; on these acquaintances future friendships are built. Such gatherings are the leaven of toil; they lift the old noses off the grind stone of daily routine, and allow an operator to get a clearer perspective of his job.

Collect a group of water works men together in any one town, at any one time, and amid all the play and noisy laughter there will be an undercurrent of shop talk, a current strong enough to smooth off the troublesome sharp edges and build up new deltas of enthusiasm for the job.

Disasters arrive without notice or invitation. If a water works is crippled or destroyed, a telephone call to fellow superintendents will start emergency equipment towards the damaged plant; operating personnel will be loaned to help with rehabilitation; and with this coöperation the dangers of water-borne infections are checked. Such aid can be requested and furnished with far greater efficiency when water works men have gone visiting about the state and have an idea of the type of supplies the neighboring plants can furnish. Call such trips junkets if you will, but at least they will prevent a request to the superintendent of a gravity supply for his extra pump.

To exchange ideas, to meet fellow workers, are the purposes of water works conventions. Serious talk in regular sessions, pleasant, friendly contact at all times, a chance to play, to renew enthusiasm, and to devlop a pride of profession. For these do you gather together, agreeing and disagreeing, and if it profiteth you not, the blame is not entirely with the program committee.

COPPER SULPHATE AS AN ALGICIDE[1]

By J. K. Marquis[2]

A knowledge of the science of microbiology is essential to a well rounded experience of a water plant chemist. Such a knowledge is much to be desired and striven for but the science cannot be learned in a day. To be able to recognize the many different kinds of algae and prescribe a remedy for their eradication requires special training combined with much practical laboratory work. The plant operator who is having his first experience with microörganisms in impounded water does not have the time to investigate the entire field of microbiology before prescribing a remedy for his trouble. He wants to know, first of all, a quick relief for his trouble, one that will give immediate results, leaving the more scientific study and research for leisure time. One effective treatment for controlling microörganisms is by the use of copper sulphate. The Spartanburg Water Works experienced considerable trouble with algae when the new filtration was put in operation in 1926.

THE SPARTANBURG WATER WORKS EXPERIENCE

The plant of the Spartanburg water works consists of a hydro-electric plant in addition to the filtration and pumping plants. The hydro-electric plant consists of two 625 K.V.A. generators driven by S. Morgan Smith water wheels. The filtration plant contains six filter units of one million gallons per twenty-four hours each. A dam was constructed forming an impounding reservoir of approximately one billion gallons of water that can be drawn upon for a water supply for the city and for power purposes. This impounding reservoir has a water surface of 360 acres. The completion and putting into service of these plants occurred during the very dry period of the month of May, 1926.

There was a lapse of time of about six weeks between the filling of the reservoir and the starting of the plant. The dry weather with

[1] Presented before the Southeastern Section meeting, April 8, 1931.
[2] Superintendent of Filtration, Water Works, Spartanburg, S. C.

the accompanying low turbidity of the water created an effective environment for the multiplication of microörganisms. Shortly after the filtration plant was placed in operation trouble began to multiply very fast. The length of time of the filter runs became less and less until we were lucky to get one and a half hours between washing. There being six filter units in operation one can imagine the amount of wash water required. The requirements for wash water greatly exceeded the capacity of the wash water equipment, necessitating the taking of water from the main. The wash water consumption reaching a maximum of around 25 percent of the pumpage. During this "hair pulling" time everything around the plant was gone over in hunting for the trouble. The filter beds were checked, dosages were checked again and again, samples of sand were collected and sent to the laboratory for analysis, the report of which showed it to be all right. As we had had but little experience with algae in a big way, we overlooked the cause. Eventually by the combined forces of the engineering staff, operators and outside authorities. it was discovered that the trouble was caused by ordinarily invisible forms who had centered their activities in the multiplication of their kind in our beautiful reservoir. Some one suggested the use of copper sulphate, a barrel of this chemical was obtained and distributed by the usual manner, by dragging around by a boat for about 1,000 feet above the dam.

The next day a change for the better was noticeable and the following night a good rest was obtained by all parties concerned.

Method of Applying Copper Sulphate

Copper sulphate was applied daily in the impounding reservoir until a 2½ inch rainfall occurred the latter part of July after which a large draft was placed upon the pond quickly causing a turnover of the water. The application of copper sulphate to our reservoir is an expensive proposition. Under ordinary conditions when we are generating only enough power to pump finished water, ten gallons of water are required to generate enough power to pump one gallon to the filtered water reservoir. Therefore, to treat out impounding reservoir would cost ten times as much as it should. Another bad effect from treating the impounding reservoir is the effect of copper on fish life. Treating the entire 360 acre water surface is out of the question. A treatment of a small portion of it just ahead of the dam is very bad practice, because of the variable draft resulting in an

under treatment part of the time, with an over-treatment at other times. The death of many fish resulted. After the break of the drought with the resulting large draft of water to operate the water wheels no further trouble with microörganisms occurred during the year.

We have a yearly occurrence of algae trouble during the summer months, especially when the rainfall is below normal. After our first year's experience in treating the impounding reservoir we changed the point of application of our treatment to the mixing chamber. There arose the question at the time as to whether the time element between the mixing chamber and the filters was long enough for the copper to do the work. We have a theoretical six-hour retention in the coagulation basin at the normal rate of operation, which we find is a long enough period to eliminate practically our trouble before the water reaches the filters.

An ordinary barrel is utilized to feed the copper sulphate solution. A hole is drilled near the bottom of the barrel into which is inserted a pipette thereby constituting a positive orifice. This orifice is calibrated and the strength of the copper sulphate is governed by the amount of algae in the water and the filtration rate. Another barrel of the solution is kept nearby so that the head in the barrel containing the orifice can be kept constant.

As the filtration rate is constant, this make-shift method of applying copper sulphate proves to be very satisfactory.

The time for the beginning of the treatment of our water with copper sulphate was governed, to a large extent, by the length of time between filter washing, rather than by the number of microörganisms per cubic centimeter. We have so far never been troubled with taste and odors in our water, the copper sulphate treatment being used solely for the purpose of keeping our filter runs up near normal. Normally the filter runs average from 100 to 125 hours before washing is necessary and are washed at 8 feet loss of head. When this time is shortened to say, 75 or 80 the treatment with copper sulphate is started.

The amount of copper sulphate used is dependent upon the number of organisms in the water. Dosages ranging from 0.2 to 1.60 p.p.m. have been used. The maximum dose of 1.60 p.p.m. occurred during May, 1930, when the rainfall was considerably below normal and the draft upon the impounding reservoir was at a minimum. Here arises the question, what is the maximum copper content that is permissible in a water for domestic use?

WHAT ARE DELETERIOUS EFFECTS OF COPPER

There seems to be a diversity of opinion among authorities on this subject as to the effect of copper on the human system. The writer made the statement that he had used as high as 1.60 p.p.m. copper sulphate just prior to coagulation and sedimentation before another Section of the American Water Works Association and started a very able discussion on the intelligent use of copper sulphate. Some present believed that I had made a mistake in the decimal point, while others discussed pro and con the effect of copper, that it was a cumulative poison, etc. Prof. George C. Whipple in his book entitled the "Microscopy of Drinking Water" states that the present hygienic standard of water purity of the United States Public Health Service has set an upper limit of 0.2 p.p.m. of copper in drinking water. He states further, that the matter of copper poisoning has been investigated by Dr. Mallory, who has established the fact that copper when taken into the system in large amounts causes the destruction of the red blood cells and a degeneration of the liver. Small quantities, he states, have so far not proved dangerous. Statements can be found in other publications that copper be limited to 0.2 p.p.m. The point I wish to bring out is that the above named authorities state that the copper content shall not exceed 0.2 p.p.m. Please note, the copper content and not the copper sulphate content. Commercial copper sulphate contains 25.4 percent copper. Therefore, a copper sulphate dose of 0.79 p.p.m. can safely be used without exceeding the copper limit. This explanation is given because sometimes the mistake is made of not differentiating between copper and copper sulphate, resulting in an insufficient dosage to eradicate the organisms.

Considering further the effects of copper on the human system, a more recent explanation of the use of copper sulphate in water supplies is given by Dr. Frank E. Hale, Director of Laboratories, Department of Water Supply, City of New York. Dr. Hale makes the statement in his 1930 revision of the Bulletin of the Use of Copper Sulphate in the Control of Microörganisms that "it seems definitely established in the negative that copper has a deleterious effect upon the health." He also states that there are many times more copper in milk and other foods than there is in a water supply after treatment and that recently important work has been done to prove that copper is beneficial in pernicious anemia. Copper is normally present in the human body and at its worst is not a cumulative poison. These statements of Dr. Hale are in direct opposition to some of the arguments I have heard on this subject.

Dr. Parker of the State Board of Health of South Carolina states that copper sulphate can be used in any quantity that is necessary to eliminate objectional organisms in a finished water supply without any bad effects upon the health of the consumers. He also states that, when uncovered clear water reservoirs become affected with algae, the sooner they are killed the better it will be for the water. He recommends supplying copper sulphate in such quantities as to insure quick elimination, the quicker the better.

COAGULATION WITH LIME AND CHLORINE

By Emil K. Ventre[1]

Several years ago Weston noted the improvement in color removal by the chlorination of raw water in treatment plants. Later, others economically used chlorine in coagulation by securing a reduction in the amount of coagulant required. Many reasons have been advanced as to why this occurred, one of the most popular of late being the oxidation of the natural iron to the ferric state, facilitating its precipitation. While this does take place, the quantitative results tend to show it a more far reaching reaction than this, and there is a definite pH where this reaction takes place. The simple oxidation of the dissolved iron by chlorine does not result in precipitation of ferric hydroxide in all waters, or rather this has been my experience in waters where the optimum pH for coagulation by the addition of previously prepared ferric iron is below 7.0.

The treatment of a low turbidity, colored water here and the search for the best coagulant, as well as for algae control, led to much experimentation in the application of chlorine. As stated before the turbidity was low, averaging 15 p.p.m. This led to a very heavy algae and protozoa growth in the river A heavy floc was needed for their removal to bottom of settling basins after being killed by prechlorination. In as much as the optimum alum coagulating pH was 6.5 the chlorine demand was very high, giving a most uneconomical condition, and the floc was light. Artificial addition of turbidity furnished no remedy. Iron sulphate and lime treatment furnished sufficient floc, aided algae control by removal of carbon dioxide, but did not remove the color completely Ferric iron did not help as it left an acid water where the alkalinity could not be built up without the return of color. The raw water contained 6.0 p.p.m. (Fe) iron mostly in organic combination and this was the source of much coloring at higher pH values.

Prechlorination was tried to remedy the color condition, but the only satisfactory condition was where iron and lime were used and this worked very well, with a great increase in the quantity of floc for

[1] Chemist and Bacteriologist, In Charge Municipal Water Purification, Monroe, La.

the chemicals applied. About this time I had occasion to visit the New Orleans, La., plant and noted the low dosage of iron applied, —0.06 grain per gallon—and this led me to try and utilize natural iron content of water for coagulation.

I may mention here that in studying the treatment reports of plants using iron sulphate and lime the period when the least amount of coagulant was used was during the summer months, when the iron content of the raw water and the turbidity was at its lowest. However, in considering the utilization of iron or its removal it is most necessary to distinguish whether the iron is due to a high percentage iron in the constituents of turbidity or whether it is in solution. Very frequently it is impossible to remove iron chemically or to get it to react even, when it is a constituent of turbidity. In some of the cases where the iron content showed lowest on analysis, actually

TABLE 1
Characteristics of the raw water (Ouachita River) average

	P.P.M.
Turbidity	15
Color	25
Alkalinity	50
Chlorides	300
pH	7.4
Free carbon dioxide	13
Iron as Fe	6

a greater amount was available for chemical reaction due to its being in solution. What is actually taking place in these plants, where a lower dose of coagulant is required during a time of lower iron content of the raw water, is that there is actually a greater amount of iron available for chemical reaction or in solution and some amount of reaction is taking place with the time.

I found, however, with this particular water that the iron-lime reaction for some reason was not complete and even when excess flocculation was secured an increase in color was noted. The same was true for alum treatment, where lime was added to raise the pH. On application of chlorine to coagulated water the water in the settling basins assumed a brown color, but gave complete color removal after filtration, denoting oxidation of the iron by chlorine and completion of reaction.

In the laboratory it was found that addition of lime resulted in the usual calcium carbonate precipitate not retained on the filters. Raising the pH with lime and adding chlorine to 0.5 p.p.m. gave flocculation beginning at pH 8.0 with optimum at pH 8.5. The floc was from $\frac{1}{16}$ to $\frac{1}{4}$ of an inch in diameter and had the physical characteristics of white iron hydroxide precipitate. Stirring resulted in almost immediate agglutination of floc and some calcium carbonate precipitate that was formed. Adding excess chlorine caused the floc to become brown, however, giving colorless filtrate very similar to results obtained in chlorination of iron and lime coagulated water.

Accordingly a plant run for a month was put on with the following filter effluent after lime chlorine treatment:

	P.p.m.
Turbidity	None
Color	None
Alkalinity monocarbonates	5.0
Alkalinity bicarbonates	52.0
pH	8.6
Iron (Fe)	0.23

No difficulty was experienced in the plant either from the change or otherwise. The effluent had a much better taste and no taste complaints were received even though for single days at a time the chloride content was as high as 450 p.p.m. Algae control was complete and filter runs increased from twenty-four hours average on alum-lime-prechlorination treatment to one hundred hours on this treatment. The chemical cost per million gallons averaged $3.18 against $9.49 on the alum-lime-prechlorination treatment, in spite of not having efficient chlorine application.

SUMMARY

1. Chlorination of coagulated water in the regular iron-sulphate-lime treatment results in more efficient color removal, protozoa and algae control, and makes iron and lime an economical treatment in cases where alone color removal would not be complete.

2. It is possible to utilize the natural iron content of water where it occurs in solution for coagulation.

3. There is an optimum and decided pH range where lime and chlorine react with iron, and for the waters I have studied, is decidedly on the alkaline side of neutrality in contrast to the previously prepared ferric coagulants whose optimum is usually on the acid side.

Less corrosive water results without necessity of supplementary pH boosting by adding of alkalis.

4. The combination of iron and chlorine are most efficient as taste removers.

5. By the use of chlorine, whether the iron is natural or applied, the reaction may be carried out without caustic alkalinity resulting, and at a minimum monocarbonate alkalinity with minimum carbonate incrustation of filter sand.

6. In some of the southern plants treating low turbidity waters, lime-chlorine, with natural or applied iron, is almost the only solution due to the high algae and protozoa content of the waters.

7. The settling time was reduced to one-third here and many of the plants now using iron and lime could efficiently prechlorinate on this basis alone.

CONCLUSION

I have carefully avoided theorizing on the action involved by the chemicals applied, for there exists now such a conflict of opinions regarding the action of chlorine in coagulation, and settlement of this problem rightly belongs to a highly equipped research laboratory. The only statement that I will make on this line is that the action of chlorination on coagulation is more than an oxidation reaction alone. Briefly, I have used lime and chlorination to secure coagulation here for a month's plant run at a chemical cost of $3.18 as compared with $9.49 per million gallons for alum-lime-prechlorination treatment. It is my intention again to operate on this treatment this coming summer and would be pleased to have any of the water plant fraternity interested to visit plant and observe its operation.

Acknowledgment is made to J. K. Brothers, General superintendent of Public Utilities and staff, without whose kind coöperation these experiments would not have been possible.

SOCIETY AFFAIRS

THE INDIANA SECTION

The twenty-fifth annual meeting of the Indiana Section was held at the Memorial Union Building, Lafayette, Ind., on March 9 and 10, 1932. Despite the depression and unseasonably cold weather, the attendance was very good. The operators' session, particularly, is increasing in popularity.

In the Round Table Discussion, W. H. Durbin called attention again to the necessity for frequent inspection of valves and hydrants in order that breaks in mains might be repaired without delay and that fighting no fire could be hampered on account of a defective hydrant.

L. D. Shively described in some detail the method used at Indianapolis in routing meter readers and the duties they are called upon to perform. Each reader averages 180 meters per day. In addition he notes evidence of leaks in the house as well as in the service In the discussion the frequency of reading was considered and while the monthly interval was most in favor, the quarterly reading was approved by some managers as an economy measure which was believed to out-weigh the advantage of frequent contact with the customer.

Under the subject "How Meters are Damaged" C. W. Winkle and Charles Streithof told of the causes of meter damage which included hot water, water hammer and sand cutting. In some instances the meters are moved from the basement to meter pits at the curb in order to relieve the danger of hot water damage. Water hammer may be eliminated partially by eliminating quick opening valves in the plants of the customers, and adequate flushing of mains will reduce the danger from sand cutting.

Clarence Goldsmith gave a particularly good paper which considered the water utilities responsibility for public fire protection. In his paper, and in the discussion, it was brought out that the old regulation requiring high pressure within a given length of time following an alarm is discarded on account of its ineffectiveness and poor economy, and pumps and sprinkling systems substituted. The

utilities' responsibility, however, includes the provision of an adequate volume under normal pressure for all fires.

Under the same general subject, R. H. Burdick, president of the Indiana Automatic Sprinkler Company, read a splendid paper on the effectiveness and economy of automatic sprinkler systems, the cost of which may be saved usually, in reduced premiums, in a period of from two to five years. The discussion brought out that payment for such service should not be on a meter basis, although meters are particularly installed to avoid theft of water, but should be based on a "standing-ready-to-serve" charge which should include cost of mains, reserve pumping capacity and available water.

The new State Department orders in regard to cross connections were explained by L. S. Finch, who listed a number of epidemics caused by such connections and illustrated the connections which will be approved under certain conditions.

Mr. Homer Rupard described a new method used by the Indianapolis Water Company for the remote control of elevated water storage.

After the evening dinner, Dr. J. A. Estey, Head, Department of History and Economics at Purdue, gave his opinion of the cause of depressions and the remedy. Dr. Estey believes that the depression is caused by the preceding boom, during which period provisions for over production are made and unreasonable savings are accumulated by certain classes. His remedy is to formulate a long time program for all public work which should be held at a minimum during normal or boom times and pushed during depression, even though need for the work may not appear until later.

Mr. J. C. Mathews of the State Board of Health described dangers to well supplies and illustrated proper methods of sealing old wells and making connections to those in service.

Eighteen states were in the recognized drought area of the last two years. Public health conditions were affected not only by the drought but by the depression, which was country wide. Dr. W. F. King described the situation in the drought area in southern Indiana where on account of state and federal aid it has been possible to avoid epidemics. In this area actually more people are protected by vaccination than ordinarily would be the case in the entire state. Dr. King emphasized the necessity for a continuation of federal aid in this respect, pointing out that every dollar spent for such work returns a handsome profit.

Mr. F. P. Stradling, superintendent of Kokomo Water Works Company, emphasized the necessity for the water works manager to maintain a friendly relationship with his community and public officials whether the plant is privately or publicly owned. Every effort should be made to completely satisfy a customer before he leaves the office.

"Tuning in on Your Customer" criticised the water works industry for failing to advertise to the public the good points of their service and the necessity for the rules and regulations imposed. The use of newspaper advertising, particularly, was recommended.

Messrs. J. A. Bruhn and H. W. Niemeyer, of the Indianapolis Water Company, discussed the pressure losses which may occur in customers' services with the resultant dissatisfaction on the part of a customer. Tests were described showing the losses which may occur in various types of services.

This was the twenty-fifth annual meeting of the water works men of Indiana. The formation of the association and its accomplishments during this period were given in a paper prepared by F. C. Jordan, secretary of the Indianapolis Water Company. On July 8 and 9, 1908, the State Board of Health held a "Pure Water Congress," at which meeting plans were made for the formation of the Indiana Sanitary and Water Supply Association which in 1924 was changed to the Indiana Section of the American Water Works Association. The typhoid fever death rate in 1908 was 32.4 and in 1931, 2.9 per 100,000 population. No small share of this improvement is due to the water works industry. The laboratory of the State Board of health examined 190 samples of water in 1908 and in 1931 a total from all sources of more than 15,000. Of the samples examined from public supplies only 4.7 were classified as bad.

Many of the members of the association pioneered in the meetings of the association and it is due largely to their efforts that Indiana now is on the typhoid honor roll of the American Public Health Association. In looking forward Mr. Jordan suggests as major activities of the association the following: (1) Increasing the tenure of office of water works officials and eliminating the haphazard appointment of them to pay political debts. (2) The establishment of water work operators' schools to improve the caliber of men entrusted with the purification of public water supplies. (3) Emphasizing the importance of complying promptly with the orders of the State Board of Health engineers. (4) The elimination, wherever

possible, of the pollution of streams and lakes and the conservation of water supplies.

Operators' Session

The program of the Operators' Session, sponsored jointly by the Section and the State Board of Health, was devoted to purification problems, and included an introduction by R. B. Wiley, Professor of Civil Engineering of Purdue University, who discussed "The Water Purification Process." The specifications which the water plant product must meet, as to safety, chemical balance and physical properties, were outlined by H. E. Jordan, in a paper entitled "The Definition of a Satisfactory Water." A valuable discussion of "Filter Sand Maintenance" was given by Frank Herring, followed by several papers devoted to specific phases of operation: "The control of Chlorination," by Clarence D. Adams; "The Determination of Turbidity of Filtered Water," by Neil Kershaw, and a demonstration of routine chemical dosage control tests, by E. H. Parks. Mr. Paul J. Cerny, in a discussion of "The Interpretation and Application of Laboratory Results to Purification Plant Operation," stressed the necessity of adequate records of operation.

C. K. Calvert,
Secretary-Treasurer.

ABSTRACTS OF WATER WORKS LITERATURE[1]

FRANK HANNAN

Key: American Journal of Public Health, 12: 1, 16, January, 1922. The figure 12 refers to the volume, 1 to the number of the issue, and 16 to the page of the Journal.

Dam Built on End and Shot into Place with Explosives. Cont. Rec. and Eng. Rev., 44: 1541–3, December 17, 1930. Brief description of unique procedure employed in construction of diversion dam at Chute-a-Caron, site of large hydro-electric development now being carried out on Saguenay River for Alcoa Power Company Limited. Usual method of coffer-daming was impracticable owing to extreme depth and high velocity. A large reinforced concrete tower, or "obelisk" was constructed, 92 feet high, 45 feet wide, and approximately 45 feet in the other dimension, containing 5,500 cubic yards of concrete and weighing 11,500 tons, lower side being shaped to fit river bottom. Obelisk was built on top of concrete pier made up of two parts, river side being so arranged that it could be shot off by large charge of dynamite, permitting obelisk to fall. Latter landed within inch of calculated position. Sealing operations were completed within 4 days, permitting construction to proceed on main dam.—*R. E. Thompson.*

Dam on Mattawan River in Isolated Part of Quebec Built with Aid of Radio and Aeroplane. Cont. Rec. and Eng. Rev., 44: 1517–23, December 10, 1930. Detailed description of construction of Toro concrete gravity dam by Shawinigan Water and Power Company, 80 miles from railway. Dam is 90 feet high and 2400 feet long on crest and required 52,000 cubic yards of concrete and 187,000 cubic yards of earth fill. Flooded area is 48 square miles in area, creating reservoir with capacity of some 1182 square mile-feet.—*R. E. Thompson.*

Foundation Procedure at Owyhee Dam. Eng. News-Rec., 106: 178–82, January 29, 1930. Foundation problems, complicated by necessity of excavating and concreting fault zone 190 feet below stream bed, have been solved at the 530-foot arched-gravity dam being built for Bureau of Reclamation for Owyhee irrigation project in eastern Oregon, and concrete placing in main structure is well started. Excavation indicated need for completely removing material from entire 250-foot length of fault zone under base of dam, volume of

[1] Vacancies on the abstracting staff occur from time to time. Members desirous of coöperating in this work are earnestly requested to communicate with the chief abstractor, Frank Hannan, 285 Willow Avenue, Toronto 8, Ontario, Canada.

excavation involved being 38,000 cubic yards, which was replaced with concrete. Methods employed are described in some detail.—*R. E. Thompson.*

Hoover Dam Plans Ready for Bidding. Eng. News-Rec., 105: 1011–7, December 25, 1930. Details are given of Hoover Dam, to be built by United States Bureau of Reclamation at Black Canyon on Colorado River, and of contract conditions and specifications on which bids will be opened on March 4th. Completion is scheduled for 7 years. Amount available for expenditure at Black Canyon is $108,000,000. Dam is concrete gravity-section structure, 730 feet high from lowest point of foundation to top and 1,180 feet long on crest, arched on 500-foot radius. Approximately 3,407,000 cubic yards of concrete will be placed. Cut-off trench will be excavated in foundation rock along upstream toe. Foundation and abutment rock will be drilled and pressure grouted to depth varying to maximum of 150 feet. Diversion of river will be effected by 4 concrete-lined circular tunnels 50 feet in diameter, all on one level and 4,000 feet long, which are designed to pass flow of 200,000 second-feet. Two will later be employed as penstocks and two, as spillway discharge conduits. Important construction feature is installation of cooling system to dissipate heat generated by setting of concrete in order to control shrinkage. Specifications require that cooling water be applied until mean temperature of concrete around each embedded pipe is reduced to 72°. Heat to be removed is approximately 700 B.t.u. per cubic yard of concrete.—*R. E. Thompson.*

Prettyboy Dam and Bridge Across Gunpowder River, Maryland. Eng. News-Rec., 105: 1031, December 25, 1930. Contract for Prettyboy concrete dam on Gunpowder River for Baltimore Bureau of Water Supply was awarded in September for $996,733. Dam is 486 feet long and 141 feet high; 133 feet above stream level. Unit prices are given from three lowest bids.—*R. E. Thompson.*

Foundation Problems Complicate Construction of Calderwood Dam. Eng. News-Rec., 105: 684–7, October 30, 1930. Description of construction of Calderwood Dam of Aluminum Company of America. Project consists of thin-section arch overflow dam 230 feet high, gravity dam 40 feet high, to form cushion pool below main dam, 26-foot pressure tunnel 2,400 feet long, and power house.—*R. E. Thompson.*

Modified Types of Gravity Dams in Relation to Uplift. FRED A. NOETZLI. Eng. News-Rec., 105: 884–6, December 4, 1930. Discussion of design problems, with particular reference to safety. Ten figures are shown, illustrating what appears to be a logical, progressive development of the gravity-type dam from enormous masonry cross-section used by ancients to modern thin reinforced concrete type. Particular attention is directed to some intermediate types of mass concrete gravity dams in which uplift pressure is greatly reduced by large drain spaces located between the individual vertical portions. Elimination of considerable portion of uplift force is considered preferable even to accurate determination of uplift and allowance for same in ordinary type of gravity dam.—*R. E. Thompson.*

Core Materials at the Germantown Dam. C. H. Eiffert. Eng. News-Rec., 105: 954–8, December 18, 1930. Data are given on core materials and pressure cell tests on 5 hydraulic-fill earth dams of Miami Conservancy District. Tests showed that cores possessed considerable stability at end of construction period. Explorations were made at Germantown Dam in 1927, about 7 years after its completion, to determine nature of core at that time. Methods of exploration employed consisted of (1) sinking shaft large enough for men to work in, and (2) sinking an ordinary well casing and obtaining sample by forcing 2-inch sampling pipe into undisturbed material below casing. Latter method was fully as satisfactory as former. Tests showed material to be ideally adapted for hydraulic-fill core. Water content, 25 percent, was practically same as that found at end of construction period at two of the other dams, materials being quite similar in each case. This would indicate that there has been little change in cores and that there will probably be very little change in future. Tests will be repeated at intervals.—*R. E. Thompson.*

Apparatus for Purifying Water by Chlorination and Dechlorination. Josef Muchka. Fr. 672,383, March 30, 1929. From Chem. Abst. 24: 2220, May 10, 1930.—*R. E. Thompson.*

Hydraulic-Fill Core Control. Charles E. Waddell. Eng. News-Rec., 105: 958–61, December 18, 1930. Method of core sampling and testing described which was first used by author and his assistants at Bee Tree Dam of Asheville water supply, an earth and rock-fill structure, 177 feet high, with volume of 850,000 cubic yards, built by semi-hydraulic-fill process. Experience seems to indicate that most impervious core is obtained when particles 0.005 millimeter and smaller constitute some 15 to 20 percent of mass.—*R. E. Thompson.*

Materials in Existing Earth Dams. E. W. Lane. Eng. News-Rec., 105: 961–5, December 18, 1930. In order to put selection of materials for earth dams on more scientific basis, United States Bureau of Reclamation is investigating materials of existing and proposed dams. Thorough search has been made of available literature, bureau files, and other sources, resulting in collection of data on composition of number of dams, to which has been added all available knowledge of history of the dams during and following construction. In order to utilize information on current projects, the data, although incomplete, have been analyzed and tentative conclusions drawn as to limits of mechanical composition of materials suitable for construction of earth dams by various methods. Data so obtained are given, analyses being shown graphically. Studies are being continued. Bureau invites engineers to contribute data which have been collected and will in return keep them informed regarding progress of studies. [Correction in Eng. News-Rec., 106: 287, February 12, 1931.—Abstr.].—*R. E. Thompson.*

Corpus Christi Dam Failure. Eng. News-Rec., 105: 974–8, December 18, 1930. Failure of La Fruta Dam of Corpus Christi water supply was caused by water passing sheet-pile cut-off at north abutment of spillway. Abutment

pulled away from weir section of spillway and fell toward earthfill, which it supported and which was breached by released water for length of about 200 feet. In addition to destruction of abutment and its foundation and training wall, about 60,000 cubic yards of embankment was carried away. It is estimated that $3,000 will cover flood damage. Details given of construction and failure, together with possible explanations. There was no evidence of defective materials or workmanship.—*R. E. Thompson.*

Engineers Report on the Failure of the Corpus Christi Dam. Eng. News-Rec., **106**: 163, 165, January 22, 1931. Salient features of report of H. E. Elrod and R. J. Cummins given. Failure is believed to have been due to excessive percolation through under-lying lenticular bed of silt, sand, gravel, and clay on which entire structure rests. Borings indicate that steel sheet-piling constituting upstream cut-off wall did not penetrate impervious bed of clay, and that seepage therefore could take place between bottom of sheet-piling and clay bed. It is believed that percolation had been proceeding for months before failure occurred. No evidence was found to substantiate theory that earthquake had contributed to failure and there was no evidence of inferior materials or workmanship. Dam can be repaired, but studies have not progressed sufficiently to justify statement of remedial measures.—*R. E. Thompson.*

The Corpus Christi Dam Failure. Eng. News-Rec., **106**: 286–7, February 12, 1931. Discussions by J. Albert Holmes and Louis E. Ayres.—*R. E. Thompson.*

Corpus Christi Dam Failure. A. K. Pollock. Eng. News-Rec., **106**: 407, March 5, 1931. Writer suggests possible cause of breaching of dam.—*R. E. Thompson.*

Public Works Construction in Australia. Harold E. Babbitt. Eng. News-Rec., **106**: 114–7, January 15, 1931. Hume dam and reservoir project involves construction of dam across Murray River just above Albury. As river forms boundary between New South Wales and Victoria at dam site, portions of dam and reservoir will be in each state. Dam, which has total length of 5300 feet and maximum height of 200 feet, involves placing of 3,893,000 cubic yards of earthwork and 532,900 cubic yards of concrete. Provision for drainage of downstream side of core wall is interesting feature. Layer of coarse gravel was placed against downstream side supported on roof of seepage and inspection gallery, which is incorporated as integral part of core wall and extends full length of earth section. Dam will create lake 50 miles long and 69 square miles in area, which will store 2,000,000 acre-feet of irrigation water. Water supply of Melbourne is obtained from uninhabited watersheds and impounded in 4 reservoirs holding 12 billion gallons. One additional dam, Sylvan Dam No. 1, is now under construction and two others are contemplated in near future. Most remote reservoir will be 80 miles from city. Dam under construction across Sylvan Valley is 1,200,000-cubic yard earth embankment, with concrete corewall, 2060 feet long, and more than 100 feet high at highest

point. Upstream face will be paved with stone blocks and downstream face will be sodded and provided with berms 20 to 25 feet apart vertically. Downstream portion of core wall is formed of hollow vertical cylindrical wells, 3 feet in diameter, on approximately 3½-foot centers, extending vertically from top of wall to within 2 or 3 feet of roof of inspection tunnel. Bottoms of wells drain independently into inspection tunnel through small drain pipes. Minimum thickness of concrete between downstream face of core wall and inside of cylinders is about 6 inches. Water supply of Sydney is also obtained from series of impounding reservoirs on uninhabited watersheds remote from city. Not all reservoirs ultimately contemplated have as yet been completed. Nepean Dam, under construction, is cyclopean masonry structure of gravity section, curved on radius of 1200 feet. It will have maximum wall height of 268 feet and concrete volume of 342,300 cubic yards and will cost $7,775,000.—*R. E. Thompson.*

Cellular Core Walls for Embankment Dams. C. H. Howell. Eng. News-Rec., **106**: 359, February 26, 1931. Brief description of new type of core wall developed during studies made in connection with certain dams for national irrigation commission of Mexico. Wall consists of row of vertical concrete cells, each draining into longitudinal conduit in base of wall discharging into outfall drains at convenient places. As any water passing through upstream sides of cells is thus discharged, dryness of dam below core wall is practically assured. Downstream portion cannot become wet unless sufficient head is built up inside cells to force water through downstream walls; which is impossible, if drains are of correct proportions. Cells and drains permit of inspection, and wall is much stiffer than solid wall having same volume of concrete. Idea was put in practice in 1917–1919 in construction of Requena Dam, about 50 miles from Mexico City, which is composite structure about 100 feet high, loose rock fill downstream of core wall and pervious mix of earth and rock upstream. Wall, which is about 600 feet long, is built of rubble masonry with reinforcement of steel bars. Cells, about 5 feet long and 2½ feet wide, are separated by partitions about 18 inches thick. Sides are about 2½ feet at top and probably batter out lower down. Many of cells are watertight, while others show considerable leakage. Total leakage at outfall is about 8 second-feet, head being 70 feet. With exception of slight seepage from crack in joint between outlet conduit and longitudinal drain conduit, entire downstream portion of dam is dry and adjacent ground dusty. Results are believed to indicate that well-designed and well-built cellular core wall with tight cut-off will ensure dry embankment below it, regardless, to great extent, of materials used and manner of placement.—*R. E. Thompson.*

Canberra, Australia's New Capital. Eng. News-Rec., **105**: 876–9, December 4, 1930. Water supply system consists of 60-foot concrete dam on Cotter River forming storage reservoir of 380 million gallons, with provision for increase to 100 feet and 1400 million gallons, respectively, and 18-inch pipe line, 4100 feet long, from reservoir to pumping station and delivering to 3-million gallon service reservoir on Mount Stromlo, with gravity supply to two other reservoirs. Electrically-operated centrifugal pumps on 3½-mile force

main to Mount Stromlo deliver against head of 840 feet. There are about 45 miles of force and gravity mains and 78 miles of city distribution mains.—*R. E. Thompson.*

Arch Dam Analysis by Trial Loads Simplified. H. M. Westergaard. Eng. News-Rec. 106, 141-3, January 22, 1931. Summary of essential steps in trial load method of arch dam analysis developed by engineers of Bureau of Reclamation. Prof. Westergaard restudied method for Bureau. His memorandum, which was also presented in paper before International Congress for Applied Mechanics at Stockholm, August, 1930, is given substantially in full, with some essential revisions by author.—*R. E. Thompson.*

Flood Control on Alluvial Rivers. T. H. Jackson. Eng. News-Rec., 106: 58-63, January 8; 105-8, January 15; and 144-8, January 22, 1931. Survey of planning problems, control, methods, and types of protection works, with particular reference to Mississippi River.—*R. E. Thompson.*

Progress in Mississippi River Flood Control. Eng. News-Rec., 106: 250-2, February 5, 1931. Summary (by Mississippi River Commission engineers) of expenditures made and construction accomplished in 2½ years.—*R. E. Thompson.*

Sacramento Sedimentation Basin Reported Near Collapse. Eng. News-Rec., 106: 203, January 29, 1931. Major findings of consulting engineers (H. D. Dewell, J. W. Ellms, and R. E. McDonnell) are: (1) that sedimentation basin of Sacramento municipal water system is in imminent danger of collapse; (2) that its repair would necessitate closing down and dewatering for several months; (3) that even incomplete repairs would cost $80,000 to $100,000; (4) that complete repair would cost approximately same as new basin of twice the capacity; and (5) that new basin would be necessary before present basin could be repaired. Bond issue of $450,000 is being urged to cover cost of new basin.—*R. E. Thompson.*

Causative Agents of Sulfate Reduction in Oil-Waters. Ray L. Ginter. Bull. Am. Assoc. Petroleum Geol., 14: 139-52, 1930. From Chem. Abst., 24: 2087, May 10, 1930. Anaërobes which reduce sulfates were found in oil-well waters. Evidence of reduction of sulfates by inanimate organic matter at fairly low temperatures was not found.—*R. E. Thompson.*

Additional Data on Sulfate-Reducing Bacteria in Soils and Waters of Illinois Oil Fields. Edson S. Bastin and Frank E. Greer. Bull. Am. Assoc. Petroleum Geol., 14: 153-9, 1930. From Chem. Abst., 24: 2087, May 10, 1930. Sulfate-reducing bacteria and hydrogen sulfide were found in salt waters in 6 producing wells 900 to 1850 feet deep. Presence of bacteria is not due to contamination, since from 8 soil and 8 fresh water samples of district only one positive test was obtained.—*R. E. Thompson.*

Design of Circular Tank of Reinforced Concrete. I. L. RASMUSSEN. Eng. News-Rec., 105: 923–5, December 11, 1930. Discussion, largely mathematical, of design of circular reinforced concrete tanks. Chief problem is to determine distance from base to point where radial movement will be entirely unrestrained, and moments and stresses which are set up between base and this point through restraint at base. A fairly easy method of doing this is submitted.—*R. E. Thompson.*

Ground Water Infiltration in Pipe Sewers. CLIFFORD OLDER and ARTHUR W. CONSOER. Eng. News-Rec., 105: 695–8, October 30, 1930. Experience with various types of joints is outlined; it is pointed out that careful workmanship, secured by rigid inspection, is more important than selection of type of joint. Infiltration in very wet ground may be safely limited to 10,000 gallons per mile per day, and in average ground to 5,000 gallons, for sewers up to 84 inches in diameter. Basing permissible infiltration on pipe diameter is not justified, it having been found that size of pipe has comparatively little effect. Measurement of infiltration by V-notch weirs placed in pipe is outlined and diagram is given showing relationship of width of trench to safe trench depth, in accordance with MARSTON's theory regarding trench width and backfill load.—*R. E. Thompson.*

Construction Costs Decrease 18 Percent in Two Years. Eng. News-Rec., 106: 195, January 29, 1931. Average unit prices are given from 5 lowest bids received on two almost identical filtered water reservoirs at Springwells Station, Detroit, contract for one being let in January, 1929, and for other in December, 1930. Cost of second reservoir, on comparable basis, was 18.5 percent lower. [Unit prices from 3 lowest bids on each reservoir given in Eng. News-Rec., 106, 343, February 19, 1931.—ABST.].—*R. E. Thompson.*

Lining Syracuse Reservoir with Gunite. Eng. News-Rec., 105: 991, December 18, 1931. Unit prices are given from bids received on 3 propositions for guniting Knapp reservoir in Syracuse.—*R. E. Thompson.*

Water Power Operation Charts Aid Reservoir Control. MELVIN D. CASLER. Eng. News-Rec., 105: 1006–9, December 25, 1930. Operation chart is described which was devised by author for budgeting available storage in reservoirs of hydro-electric power plants.—*R. E. Thompson.*

Making Rapid Field Examinations of Flood Control Reservoir Sites. J. ALBERT HOLMES. Eng. News-Rec., 106: 386–8, March 5, 1931. Details given of methods employed by Mississippi River Commission for obtaining physical and economic data on sites for flood control reservoirs. In addition to 6 economic surveys on rivers, 14 dam and reservoir sites were examined during period of 4½ months.—*R. E. Thompson.*

Water Improvements for Meeker, Colorado. Eng. News-Rec., 105: 753, November 6, 1930. Details given of 3 lowest bids on improvements to Meeker supply system, including supply line, distribution system, and 0.5-million gallon steel tank.—*R. E. Thompson.*

The Drought of 1930. F. H. NEWELL. Eng. News-Rec., **106**: 237-9, February 5, 1931. Rainfall data, tabulated and graphical, are given and discussed. Averaged over entire country, 1930 rainfall (25.6 inches) was 13 percent below normal. These figures were compiled from observations at 5,000 stations, grouped by states and weighted according to state area. Complete monthly rainfall statistics by states are included. Water supplies were seriously and extensively affected throughout Eastern half of country. Authors draw following conclusions from facts presented. (1) Hydrologic data are too few and too slowly compiled, and ground water data are almost absent. There is need for research into phenomena of quantity, quality, and movement of ground water and their effect on stream flow. Fuller development and coordination of stream flow data are also needed. (2) Factor of safety in many water supplies is too low to give adequate protection in abnormally dry seasons.—*R. E. Thompson.*

Water Supply in Drought Regions. Eng. News-Rec., **106**: 366-7, February 26, 1931. Discussion of effects of drought on Illinois water supplies. Since March, 1930, rainfall for state as whole shows deficiency from normal for each month with exception of September, in which month precipitation was 101 percent of normal. Yearly rainfall (1930) was 77 percent of normal. Of 523 cities and villages in state having public water systems, 107 derive supplies from surface sources and remainder from springs and wells. Conditions in individual towns are outlined.—*R. E. Thompson.*

Field Notes on Water Supply Conditions in Drought Areas. Eng. News-Rec., **106**: 405-6, March 5, 1931. Data are given on effects of drought in Missouri and Indiana. In Missouri as whole, rainfall during 1930 was 79 percent of normal. Owing to depletion of supply at Harrisonville, pumping into mains has been limited to one-half hour each day. Records show large increase in typhoid death rate in Missouri during last 6 months of 1930 compared with corresponding period of 1929. Increase is most pronounced in counties most severely affected by drought, but is also evident in cities whose supplies have never been in danger. Indiana has largely escaped serious water supply deficiencies. Precipitation during 1930 averaged 29.70 inches as compared with normal of 39.29, or 75.6 percent. Program of complete metering was inaugurated during summer in Bloomington in effort to reduce consumption, which at that time was 2.5 million gallons. Although program still lacks 60 days of completion, consumption has already been reduced to 1.5 million gallons per day. Brief data included on condition of various supplies in both states.—*R. E. Thompson.*

Spiral-Welded Product Enters Pipe Line Field. Eng. News-Rec., **106**: 415, March 5, 1931. Recently developed spiral-welded steel pipe is described briefly. Pipe is made in diameters from 6 to 24 inches, lengths of 30 and 40 feet, and of any wall thickness. It is claimed that spiral joints serve as stiffeners to walls of pipe and also that they compensate for shrinkage, resulting in straight, round pipe.—*R. E. Thompson.*

Repairs Inside 54-inch Steel Water Pipe Made Under Pressure. J. S. LONGWELL. Eng. News-Rec., 106: 109–11, January 15, 1931. Aqueduct recently built by East Bay Municipal Utility District to convey water from Mokelumne River to cities on east side of San Francisco Bay crosses San Joaquin River in inverted siphon about 600 feet long. At this point line consists of 2 steel pipes, each 54 inches in diameter, coated on outside with 4 inches of gunite. Pipe was fabricated in 30-foot lengths, made up of 2 semi-cylindrical sections of ½-inch plate welded together electrically. At low water level siphon is under external pressure of about 40 feet, internal pressure under ordinary conditions being about 230 pounds per square inch. After completion, but before connection to pipe over levees, tests showed that north pipe was leaking at rate of 94.07 gallons and south pipe at rate of 24,000 gallons per mile-inch per hour. Inspection of latter, inside and outside, by diver while pipe was full of water (to prevent floatation) failed to disclose leak. Pneumatic chamber or air lock was then constructed which could be moved through pipe, stopped at any intermediate point and there unwatered so that detailed inspection could be made in the dry. Air lock consisted essentially of two wooden bulkheads 9 feet apart, connected by framework of 4-by 6-inch timbers, water-tight joint being made by means of inflated fire hose. Crack was discovered at right angles to upper longitudinal weld and extending 5 or 6 inches on either side of it. Repair was effected inside pneumatic chamber by opening cracks by V-cuts with air-chipping tools and filling by electric welding. Weld was finally chipped flush with inside pipe surface and covered with ½-inch plate, 8 by 12 inches, welded to pipe on all 4 sides. Crack of practically same length and location was found in exterior gunite coating. This was repaired by placing concrete collar around pipe. Tests then showed leakage of 172.5 gallons per mile-inch per 24 hours, which is well within that allowed for this portion of aqueduct.—*R. E. Thompson.*

Metallurgy of Valve, Fitting, and Piping Materials. L. W. SPRING and H. W. MAACK. Metals and Alloys, 1: 446–9, 1930. From Chem. Abst., 24: 2700, June 10, 1930.—*R. E. Thompson.*

Determination of Pipe Diameters for Maximum Economy. C. W. HARRIS. Eng. News-Rec., 106: 101, January 15, 1931. Determination of economical diameter of pipe lines is discussed and physical analysis upon which mathematical treatment of subject is based is outlined. Well known ADAMS principle leads eventually to conclusion that any pipe installed with constant factor of safety throughout an irregular profile should be smaller at points subjected to greater pressure. From this and other simple relationships it has frequently been shown that diameter of high pressure steel pipe should vary from point to point in such manner as to remain inversely proportional to 7th root of pressure head for which pipe is designed. This is true regardless of total head assigned for overcoming friction. Purpose of pipe line and unit costs of materials need not be considered, and pipe line once installed according to this method has its material correctly distributed regardless of any change in service that may later be imposed upon it. For example, even if,

by permitting greater friction loss, quantity of water is doubled, or trebled, pipe will still be correctly proportioned.—*R. E. Thompson.*

New Formula for Friction Losses in Steel Pipe. FRED C. SCOBEY. Eng. News-Rec., 106: 273–4, February 12, 1931. Data given from Technical Bulletin 150 of United States Department of Agriculture, in which new formula is presented for calculating friction losses in steel pipe lines under pressure, based upon experiments conducted by Department and upon all other available data on steel pipe lines, involving 1178 observations on 198 reaches of pipe, some of which were made as early as 1850 and others as recently as 1929. Study of data yields expression,

$$H = K_s \frac{V^{1.9}}{D^{1.1}}$$

where H is loss of head due to friction, in feet per 1000 feet; K_s is coefficient dependent on pipe characteristics, such as plate thickness, type of jointing, and age; V is average velocity of water in feet per second; and D is average diameter of pipe in feet. All pipes tested were coated with bituminous material, age varying from new to 47 years and diameter from 4 to 168 inches. Flow ranged from 0.89 to 982 second-feet, and velocities from 0.65 to 22.9 feet per second. In Department experiments, velocities were measured directly by timing passage of cloud of color. Diagram constructed to facilitate use of formula is included.—*R. E. Thompson.*

Flow in Silt-Laden Canal Gaged by Contracted Flume. R. L. PARSHALL. Eng. News-Rec., 106: 183–5, January 29, 1931. Bulletin 336 of Colorado Agricultural Experiment Station, entitled "The Improved Venturi Flume," describes development of measuring device for open channels which possesses characteristics of accuracy of measurement, freedom from trouble due to silt or sand, and ability to withstand high degree of submergence without affecting free-flow rate of discharge. Largest unit of this type yet constructed is 40-foot reinforced-concrete installation located about 1½ miles below head of Fort Lyon Canal, near La Junta, Colorado. Channel is 75 feet wide at bottom, 7 feet deep, and has capacity of about 1800 second-feet. The water, taken from Arkansas River, carries excessive amounts of silt and sand, resulting in deposits in canal, which render ordinary type of rating flume entirely unsuitable. Construction details are described and illustrated. Flume contains 215 cubic yards of concrete and cost was approximately $6,300. Twenty-one current meter gagings have been made since completion, with flows of 128 to 1464 second-feet, maximum deviation from computed discharge being 2.3 percent, computed value being higher in 11 cases and lower in 10. Note by Editor points out that owing to objection to term "improved Venturi flume," on ground that device is not, strictly speaking, a Venturi flume, name has been changed to "PARSHALL measuring flume."—*R. E. Thompson.*

Determining Coefficients for Large Venturi Meters. S. F. COGHLAN. Eng. News-Rec., 106: 185–6, January 29, 1931. Calibration of 26 Venturi meters, ranging from 30 to 72 inches in diameter, was recently completed on hydroelectric system of Southern California Edison Company, standard coefficients

having showed inconsistencies. Tests were made by salt-velocity method, time being recorded electrically. Results indicate that coefficients are more constant for meters with gradual transition from inlet to throat. Caution must be observed in applying coefficients for small standard Venturi meters to large special installations. For latter and in cases of special flow conditions, such as proximity to valves or branches, discharge coefficient should be determined for each individual case by careful independent discharge measurements.—*R. E. Thompson.*

A Practical Venturi Meter for Irrigation Service. J. E. Christiansen and I. H. Teilman. Eng. News-Rec., **106**: 187–8, January 29, 1931. Adaptation of Venturi meter to irrigation at reasonable cost has been recently accomplished in Consolidated Irrigation District near Fresno, California. Development was result of effort to eliminate difficulties common to usual devices used to measure irrigation water. Built of precast concrete tubes, about 50 meters ranging in size from 16 to 42 inches were placed in service during 1929–1930 season and found practical under conditions of actual field use. Calibration tests on these meters and on half-size model, which resulted in simplification of ordinary formula, have proved meters to be sufficiently accurate for this type of service. Venturi tube itself costs but little more than equal length of plain concrete pipe which it replaces and measuring well costs about $5. Meters and their calibration described and modified formula given.—*R. E. Thompson.*

Special Master Recommends Limited Diversion of Delaware River Water by New York City. Eng. News-Rec., **106**: 284–6, February 12, 1931. That diversion, under suitable restrictions, of equivalent of 440 million gallons per day from tributaries of Delaware River for domestic use in New York City should be permitted by United States Supreme Court is conclusion reached by Charles N. Burch, special master, in report submitted to that body on February 2. Suit was instituted by New Jersey to enjoin proposed development by New York City of certain tributaries of Delaware River lying wholly within New York State as 600-million gallon per day addition to water supply system of city. Pennsylvania, although not opposing diversion, intervened in suit to safeguard its own interests. New York had planned the development in 3 stages. First and second, covering Neversink and East Branch, which would provide 440 million gallons per day, is approved by special master. Third stage, which is not granted, would include Little Delaware, Willowemoc and Beaver Kill, adding 160 million gallons per day. Rondout Creek, a part of project not included in present suit, would yield additional 70 to 100 million gallons. All 3 states maintain, with certain exceptions, rule of common law with respect to riparian rights, *i.e.*, that riparian owner has right to enjoy, without substantial diminution, or alternation, natural flow of stream past his property. Strict interpretation of this rule would forbid any diversion, but master believes that, in case of such importance, court should not confine itself to common law alone, but should also give consideration to statute laws and public policies of 3 states and to principles of what may be termed "interstate common law," a code built up by courts to govern relationships among

states. Furthermore he finds that there is much latitude in word "substantial" as applied to permissible diminution of flow under common-law rule. New Jersey contended that, before being permitted to resort to tributaries of Delaware River, city should be required to conserve water by system of universal metering and by charging adequate rates, and also that other possible sources not affecting interstate streams should first be exhausted. These contentions are held to be not without merit; however, master finds that universal metering would be extremely expensive; would, at best, do no more than defer necessity for more water for approximately 5 years; and that present per capita use of water in New York is not excessive. Master finds that although no single item of damage which would be incurred by New Jersey through 600-million gallon per day diversion would be serious, or substantial, total of all such items indicate damage to amount greater than that state should be required to suffer. Such injury can be abated by (1) reducing volume of diversion; (2) modifying plan of releasing water from impounding reservoirs during low stages of river; and (3) treating industrial and sewage wastes at Port Jervis. Of Pennsylvania's contentions, master approves three: (1) that river water should be apportioned among 3 states; (2) that present diversion shall constitute part of New York's allotment, not a prior appropriation; and (3) that Pennsylvania's plan of releases is preferable to that approved by New York.—*R. E. Thompson.*

Diversion of Connecticut Tributaries for Water Supply of Boston Upheld. Eng. News-Rec., **106**: 399–401, March 5, 1931. Details given from Supreme Court decision in suit brought by Connecticut against Massachusetts to prevent diversion from tributaries of Connecticut River to provide additional supply for Boston Metropolitan District. First important water supply was brought to Boston from Lake Cochituate in 1848. Proceeding westerly, the Sudbury was added in 1878 and the Wachusett in 1906, delivering water into Sudbury system, with Weston aqueduct supplementing the Sudbury aqueduct. Wachusett-Coldbrook tunnel to convey flood-flow of Ware River to Wachusett reservoir has just been completed. Next will be built an extension to proposed reservoir on Swift River, through which water will flow, on occasion, in either direction, together with dams to form reservoir. When Wachusett reservoir at westerly end of tunnel is full, flood-flow of Ware River will be sent westward into proposed storage reservoir on Swift River to be returned through same tunnel when there is room for it in Wachusett reservoir. Easterly, or Wachusett-Coldbrook tunnel, is 14.2 miles long. It was holed through in 1930 and is now practically ready for use. Bids for construction of 10.4-mile westerly section will be received shortly. Tunnel, throughout, is of horseshoe shape, 12¾ feet high and 11 feet wide. Two dams forming Swift River reservoir will not be built at present. Court supports special master CHARLES W. BUNN's findings both of fact and law, it being first time that Supreme Court has ruled in conflict over interstate water rights in which both states have adopted common law doctrine that riparian owners have right to undiminished flow of water past their land. Both rivers involved, the Ware and Swift, are wholly within State of Massachusetts. Both are tributaries of Chicopee, which empties into Connecticut River just above Springfield, Massachusetts. Two

substitute projects proposed by Connecticut were ruled out and Connecticut's bill of complaint dismissed without prejudice to her right to maintain suit against Massachusetts whenever it appears that substantial interests are being injured. Decision states that laws in respect of riparian rights that happen to be effective for time being in both states do not necessarily constitute dependable guide or just basis of decisions on controversies such as here presented. Rules of common law on that subject do not obtain in all states, and there are variations in application. Doctrine of appropriation prevails in some states and every state is free to change its laws governing riparian ownership and to permit appropriation of flowing waters for such purposes as it may deem wise. Serious water shortage in near future faces Boston and other 34 cities and towns comprising Metropolitan District. Present population of district is 1,900,000. Nearby cities and towns which may soon be admitted to district have population of 960,000. It is estimated that, in 40 years, population dependent upon Metropolitan water supply will reach 4,572,000. Details of diversions from Ware and Swift Rivers allowed by War Department permits are included.—*R. E. Thompson.*

Studies of the Sea Water Near the Puget Sound Biological Station During the Summer of 1927. THOMAS G. THOMPSON, ROBERT C. MILLER, GEORGE H. HITCHINS, and SELDON P. TODD. Pub. Puget Sound Biol. Sta., 7: 65–99, 1929. From Chem. Abst., 24: 2018, May 10, 1930. Dissolved oxygen content and that of carbon dioxide are related primarily to rate of photosynthesis as influenced by light and temperature. In progressing from surface to bottom there is increase in chlorinity and total carbon dioxide, and decrease in temperature, dissolved oxygen, and pH value. Discussion of carbon dioxide-carbonate equilibrium of sea water is included. Titrimetric methods are not applicable to determination of carbon dioxide in water.—*R. E. Thompson.*

The Strength and Annealing of Welded Joints. HÖLZERMANN. Metallbörse, 19, 2721–2, 2779–80, 1929. From Chem. Abst., 24: 2095, May 10, 1930. Characteristics of welds made with varieties of iron and steel are pointed out. Greater attention should be paid to elastic properties of weld, rather than simply to tensile strength. For some of newer alloy steels, only beryllium alloys (1–2 percent) have proved satisfactory as welding agents.—*R. E. Thompson.*

Cleaning Rust from Water Pipes. E. L. CHAPPEL. Domestic Eng., 129: 3, 63–5, 85, 1929. From Chem. Abst., 24: 2096, May 10, 1930. Rust is removed by use of hydrochloric acid and inhibitor; consideration is given to composition of rust solvent, determination of complete rust removal, prevention of rusty water, waste acid used to clean drains, and prevention of rust in lines after cleaning.—*R. E. Thompson.*

Developments in Western Municipal Water Supply Practice. HARRY N. JENKS. Eng. News-Rec., 106: 438–40, 1931. Esthetic value of mountain water is being weighed against cash value of cheap supply. Source of supply was formerly considered of prime importance, whereas now quality of water

as delivered to consumers holds that position. In light of experience and envisaging advantages of modern purification practice, it appears that some Pacific coast mountain supply projects lack full economic justification. Consideration of existing supplies from distant mountain watersheds leads to conclusion that it may be less expensive and more reliable to filter the water than to provide increasingly elaborate watershed protection now demanded. Practically all mountain sources, through either natural or artificial causes, are becoming less desirable in regard to quality and in recent years water from practically every source, even under apparently ideal conditions of mountain catchment area, has been subjected to some form of treatment. In California, most striking development is reclamation of water from municipal sewage and storm water drainage. Some salient characteristics of western municipal water supplies and comparative cost statistics are tabulated. Many outside factors prevent definite comparisons between cost of water and domestic consumption thereof. It is reasonable to assume, however, that the abnormally low consumption of East Bay cities, of which Berkeley (65 gallons per capita per day) is typical, is reflection of cost of water, which in turn reflects cost of supply project, which involved capital outlay of approximately $60,000,000 for population of about 500,000. In addition to estimated cost of domestic water of 39.4 cents per 1000 gallons, there is a district tax which makes actual cost in valuable residential areas in excess of 50 cents. Alternative project, proposed at same time, to utilize floodwaters of Sacramento River, could have been financed, according to an engineering report, by the difference alone between the two projects in respect to bond interest and retirement charges.—*R. E. Thompson* (*Courtesy Chem. Abst.*).

Bacteria, Chemotherapy and Environment. Kurt Ziegler and M. Dorle. Z. ges. exptl. Med., **72**: 197–210, 1930; cf. following abstract. From Chem. Abst., **24**: 5782, November 20, 1930. Effect of various colloidal substances upon action of metal salts on bacteria was demonstrated. *In vitro* studies of chemotherapeutic agents on bacteria should include studies in various colloidal environments.—*R. E. Thompson.*

The Adaptation of Bacteria to Metallic Salts. Kurt Ziegler and M. Dorle. Z. ges. exptl. Med. **72**: 178–96, 1930; cf. preceding abstract. From Chem. Abst., **24**: 5782, November 20, 1930. *B. typhosum*, *B. coli*, and other organisms showed definite adaptation to copper and other metals, adaptation being greater when concentrations in subcultures were changed slowly. No adaptation to silver was observed. Washing with sodium thiosulfate destroyed the adaptation and authors conclude that resistance to metallic poisons is in the surface layer of the bacteria. Bibliography appended.—*R E. Thompson.*

The Bacteriophage Content of Sewage and Its Action upon Bacterial Organisms. T. D. Beckwith and Edythe J. Rose. J. Bact., **20**: 151–9, 1930. From Chem. Abst., **24**: 5787, November 20, 1930. Many, but not all, strains of bacteriophage are resistant to chlorine as used in chlorination of sewage. The phages can inhibit bacterial growth and to some extent decrease growth. Non-lactose fermenters are more susceptible than lactose fermenters.—*R. E. Thompson.*

The Entrainment of Water from a Steam Boiler. CHR. EBERLE. Arch. Wärmewirt., 10: 329–33, 1929 From Chem. Abst., 24: 5897, November 20, 1930. Experiments with small-scale apparatus show that above atmospheric pressure foaming begins when a certain volume of steam is generated per minute; below atmospheric pressure the limiting volume increases. Foaming decreases as depth of liquid through which bubbles pass decreases. Dissolved and suspended solids increase foaming.—*R. E. Thompson.*

Montana Public Water Supplies. Montana Department of Public Health, June 19, 1930. There are 126 public water supplies furnishing water to 112 cities, towns and institutions in the State. About 50 percent of all water supplies come from surface streams and the balance from wells or springs. The majority of the public water supplies are of satisfactory sanitary quality. A small liquid chlorine plant is available for emergency uses at all times. The flood at Wibaux, June 7, was controlled so that not a single case of typhoid resulted from the contaminated water.—*A. W. Blohm (Courtesy U. S. P. H. Eng. Abst.).*

Report on Water Supply at Regina, Sask. Canadian Engineer, 59: 1, 107, July 1, 1930. Data are given from preliminary report by R. O. Wynne-Roberts and Nicholas Hill, regarding proposals for increasing the water supply of Regina. The normal consumption is approximately 4 m.g.d. The supply from the existing sources is as follows: Boggy Creek, 5 m.g.d.; Mallory Springs, 1 m.g.d.; Tregarva Springs, 2 m.g.d.; municipal wells within the city limits. The recommendations are (1) further prospecting for additional supplies at Boggy Creek; (2) replacement of pipe line between Tor reservoir and the compensating reservoir; (3) development of Mound Springs, 14 miles north of the city; (4) laying of a pipe line from Mound Springs to a proposed new reservoir north of the city, tentatively named Albert reservoir; (5) laying of a pipe line from Albert reservoir to the present city reservoir; (6) prospecting at Dickson, Cooper and Arrow Head springs. The ideal, and probably the ultimate source of supply is the South Saskatchewan River. This supply, however, would have to be pumped 108 miles, and owing to the cost of such a scheme consideration of the source is deferred until a later date. The hardness of the river water is only 170 p.p.m., compared with the 634 p.p.m. of the present supply. The cost of the recommended extensions is estimated at $6,000,000 to $14,000,000, depending on the pipe line material used.—*A. W. Blohm (Courtesy U. S. P. H. Eng. Abst.).*

Results of Carbonation in Water Softening Plant. CHARLES M. SPAULDING. Water Works Eng., 83: 16, 1169, July 30, 1930. Detailed methods of applying the lime and a description of the carbonating equipment at the Springfield, Ill. plant are given. The recarbonation of the settled water is accomplished with stack gas at a cost of 44 cents per million gallons. No chlorophenol tastes have developed from the use of this gas. Spaulding states that when settled water of pH 10.8 is recarbonated to 9.3 it is extremely unstable, and it does not seem advisable to continue the treatment. This instability of the water incrusts not only the sand but also the conduit and valves leading to the filters.

Bacterial tests indicate that sterilization with lime is a slow process and not at all comparable with chlorination.—*A. W. Blohm* (*Courtesy U P. P. H. Eng. Abst.*).

Portable Laboratory Kit for Filter Plant Control. K. W. Grimley. Public Works, 61: 4, 141, April, 1930. As a part of a program by the Sanitary Engineering Department of the Jefferson County Health Board for closer supervision of the filter plants, a portable laboratory kit was assembled for making the needed chemical tests at the plants. The tests include alkalinity—total, carbonate, bicarbonate and caustic; approximate hardness—total, carbonate and non-carbonate; pH; free CO_2; residual chlorine; and residual aluminum sulphate. Tests are run on raw, settled and filtered water, and the results, together with operating data, are recorded on special blanks.—*A. W. Blohm* (*Courtesy U. S. P. H. Eng. Abst.*).

Water Supply at St. Catharines, Ontario. Canadian Engineer, 58: 10, 316, March 11, 1930. During the summer months the condition of the water from the Welland Ship Canal continued to be very bad but once again the filtration plant proved its efficiency by producing a satisfactory supply. The dosage of alum varied from 0.5 to 0.94 g.p.g., averaging 0.62. Chlorine application was practically constant at 2 pounds per million gallons. The daily average consumption was 4,499,925 gallons, the maximum being 7,454,080 and the minimum 3,046,240. Exclusive of the metered industrial, commercial and suburban supplies, the average daily per capita consumption was approximately 112 gallons. The cost of plant operation during the year was $9,497.92, a slight increase over 1928. The revenues for the year showed a gratifying increase over previous years.—*A. W. Blohm* (*Courtesy U. S. P. H. Eng. Abst.*).

Twenty-fourth Annual Report of the Board of Water Supply of the City of New York. January 1, 1930. This report of the Board of Water Supply for the year ending December 31, 1929, contains a summary of the activities prepared by the Commissioners, reports of the administrative, police and claims bureaus, report of the auditor with extended financial statement and report of the chief engineer of the Board. Of major importance has been the start of construction of City Tunnel No. 2, 20 miles long, extending from Hill View reservoir in the City of Yonkers through the Bronx under East River at Rikers Island and thence through the Borough of Queens to the intersection of Hicks Street and Hamilton Avenue in Brooklyn. This pressure tunnel is to be concrete-lined, 21 feet in maximum diameter, with 17 shafts provided with steel risers through which water is to be fed into the distribution system. Preliminary work has also been continued toward provision of a new water supply from Rondout Creek and from certain eastern tributaries of the Delaware River watershed in the State of New York. The construction of a sewerage system and disposal works for the Village of Grand Gorge is also under way. Descriptions of construction methods employed on these projects are found in the report of the Chief Engineer. Tabulations of rainfall and of stream flow of the gathering area are also included.—*A. W. Blohm* (*Courtesy U. S. P. H. Eng. Abst.*).

Waterworks at Sao Paulo, Brazil. Fred W. Freise. Gas. u. Wasserfach, 73: 398 (1930). Chemical Abstracts, 24: 14, 3580, July 20 1930. "Statistics are given for the water supply of Sao Paulo. One project, to use Rio Claro water, has been temporarily abandoned on account of limited supply, and water is being bought from a hydroelectric system and purified by alum-lime treatment followed by settling. After filtering, the water is chlorinated."—*A. W. Blohm (Courtesy U. S. P. H. Eng. Abst.).*

The Biological Sieve Process in Investigating Potable Water. Herbert Beger. Gas. u. Wasserfach, 73: 434, (1930). Chemical Abstracts, 24: 14, 3582, July 20, 1930. "The determination of the sediment from water to be used for drinking purposes is a very useful means for determining the origin and quality of drinking water. At least 100 liters of water should be filtered through the sieve. Instead of rejecting the first portion of water from the tap this should be included as it usually contains more sediment than later portions. The design of the sieve is illustrated, and precautions to be observed are given. Results of typical tests and their interpretation are given."—*A. W. Blohm (Courtesy U. S. P. H. Eng. Abst.).*

Lime-Soda Ash Softening of Municipal Water Supplies. Jacob G. Hack. Fifth Annual Report of Missouri Water and Sewerage Conference. A popular discussion of the cause and nature of hardness in water, including the benefits of soft water, is followed by an explanation of the detail and chemistry of the oldest procedure in use for softening water; the application of lime and soda ash, which, with certain modifications, is applicable to any water. A discussion of recarbonation, the actual plant operation and control of a municipal lime-soda ash plant and the numerous causes of trouble is given.—*A. W. Blohm (Courtesy U. S. P. H. Eng. Abst.).*

Further Information on the Differentiation of Organic Substances in Water: the Chlorine-Combining Power of Ground Waters. Keiser K. Tech. Gemeindebl., 1929, 32: 183 and 195. In former paper (Tech. Gemeindebl., 1928, 31: 81), relation between oxygen demand and chlorine demand was shown to be valuable criterion of source of organic impurities. This relation was examined in 108 samples of Elbe water, 36 raw, 36 after sedimentation, and 36 filtered, taken at intervals during a year. Results are shown in tables and curves and agree with those previously obtained. At times of fairly high temperature, oxygen-demand and chlorine-number curves approach each other, but at times of frost, when biological processes of decomposition are hindered, chlorine number rises sharply. Tables are also given showing chlorine and oxygen demand and also gauge readings and temperature of Elbe water at Artlenburg and at Hamburg intake. These show influence of volume of flow on condition of water. Sufficient storage leads to natural sedimentation and biological self-purification. London water from Thames and New River is allowed two months' storage. Artificial precipitation removes more of oxidizable, than of chlorine-combining substances. In natural sedimentation, on the other hand, as shown by a series of experiments with different river waters stored for 4 weeks, results of which are given, this situation is reversed; which fact gives

storage its special value in improvement of water. Conditions are then discussed which have led to construction of numerous impounding reservoirs at suitable locations, both for power and for supply purposes. Such reservoirs must be protected from pollution and must afford storage of at least between 1 and 2 months for bacteriological purification. Relation of oxygen-demand to chlorine number will show whether further purification is then necessary. Extension of Hamburg's ground water supply furnished opportunity for comparative examination of number of different ground waters. Here, also, source of organic constituents can be judged from results of simultaneous estimation of oxidizability and chlorine-combining power. No relation was discernible between contents of iron and ammonia on one hand and chlorine number on the other. Results of experiments to test influence of iron and ammonia on estimation of chlorine-combining power by Froboese's method are tabulated. Reference is made to work of Austen on permanganate demand and chlorine number of waters containing much iron.—*M. H. Coblentz* (*Courtesy of the Department of Scientific and Industrial Research, Water Pollution Research Board, Summary of Current Literature*).

The Alkaline Reserve of Sea Waters. Margaria, R. Nature, 1929: 124, 168. Reference to paper read before Royal National Academy of the Lincei. Experiments on capacity of sea water to fix carbon dioxide showed that normal alkaline reaction was displaced, in perfusion of surviving organs, towards acid side by carbon dioxide produced by the tissues, and, possibly, to pH values even less than that of cell fluids. It cannot, however, be assumed that this phenomenon would occur, since tisues have sufficient regulating power to enable them to confer their characteristic reaction on perfusion liquids.—*M. H. Coblentz* (*Courtesy of the Department af Scientific and Industrial Research, Water Pollution Research Board, Summary of Current Literature*).

Corrosion and Water Purification Problems in the Light of New Electrical Investigations. Haase, L. W. Chem. Ztg., 1929, **53**: 653. In paper read at meeting of Verein für Wasser-, Boden-, u. Lufthygiene, author describes how water in equilibrium, that is, neither corrosive nor protective, can, under certain circumstances, form protective coating. Chemistry of deposition is explained and danger to mains from excessive deposits is discussed. In all kinds of water, presence of oxygen is important. The waters intermediate between those definitely corrosive and those definitely protective are of great economic importance. In these, contents of carbon dioxide and of oxygen are less important than mineral composition which determines whether, or not, protective coating of lime will form. Lack of oxygen can be remedied by aëration, and lime can be added to achieve desired conditions.—*M. H. Coblentz* (*Courtesy of the Department of Scientific and Industrial Research, Water Pollution Research Board, Summary of Current Literature*).

Comparison of Some Customary Methods for the Detection of B. Coli in Water and the Estimation of the Coli-Titer. Segre, S. Zbl. Bakt., Parasitenk., II, **78**: 105; Chem. Zbl., **1929**: 2, 923. Italian Ministerial Decree prescribes as standard for drinking water, absence of *B. coli* in 250 cc. Author

concludes that for this quantity, best method of estimation is that of PARIETTI, which is both sensitive and economical in material.—*M. H. Coblentz* (*Courtesy of the Department of Scientific and Industrial Research, Water Pollution Research Board, Summary of Current Literature*).

Determination of Bromine in Sea Water and Estuary Waters. KOGAN, A. I. Ukraine Chem. J., 1928: 3, 131; Brit. Chem. Abst. A, September, 1929, 1029. Methods for determining bromine in presence of large quantities of chlorine and their applicability to bromine in sea water are discussed. WEZELSKY'S method is inapplicable, but BERG'S method gives good results. Three drops of 20 percent sulphuric acid are added to 10 cc. of sea-water and then chlorine water, until maximum color obtained. Solution is then shaken with 5 cc. of chloroform and color compared with that similarly obtained from solution of known weight of potassium bromide in estuary water from which bromine has been removed. If ordinary water is used as solvent, results obtained are too low.—*M. H. Coblentz* (*Courtesy of the Department of Scientific and Industrial Research, Water Pollution Research Board, Summary of Current Literature*).

Ammonia-Chlorine Reactions and Lime-Chlorine Process. LINN H. ENSLOW. Water Works & Sewerage, 78: 55–59, 1931. In chlorination of waters, or sewages, which contain ammonia, artificially supplied if not naturally present, there will be produced one or more of the following, viz., valuable chloramines, less valuable nitrogen trichloride, or valueless ammonium chloride. When ammonia enters waters, NH_4OH is produced and, thereafter, carbonate, or bicarbonate. Chlorine entering water produces HOCl and, if water is caustic, $Ca(OCl)_2$. Reaction between available chlorine and ammonium ions produces chloramines (NH_2Cl, $NHCl_2$, NCl_3). If ammonia is present in sufficient excess, hydrazine hydrochloride, of low germicidal value, or NH_4Cl, having no germicidal value, is produced. In pH zone of 4.4 to 5.5 dichloramine ($NHCl_2$) is produced; between pH 5.0 and 8.4 both $NHCl_2$ and NH_2Cl, and at pH 7 mixture containing roughly 50 percent of available chlorine in each form will result. At pH 8.4, or above, as for prevention of corrosion, NH_2Cl only is formed. Softened water recarbonated to pH from 7.5 to 7.8 should have between 70 to 90 percent chloramine present in mono-form. This will occur when the ratio of NH_3 to Cl is as 1 to 4 by weight. Lowering of pH will convert mono-form to dichloramine. Regardless of form of active chlorine applied, rate of destruction of bacteria is radically affected by changing pH of medium. In waters of high pH, high residual chlorine concentration will have to be maintained, if rapid disinfection is required. Above pH 8.0, rate of bacterial destruction in water may be retarded for a given residual chlorine value, whereas under pH 7.0, efficacy of small residual chlorine content increases. Temperature has also a marked effect. Chloramine chlorine disappears more slowly from water, but it is not so powerful a disinfectant as chlorine alone. Chloramine solutions can be prepared by production of hypochlorous acid from chlorine water and thereafter adding ammonia water, or an alkaline solution of some ammonia salt.—*C. C. Ruchhoft* (*Courtesy Chem. Abst.*).

Correcting for Errors Caused by Manganese in the Residual Chlorine Test. LINN H. ENSLOW. Water Works and Sewerage, **78**: 183–4, 1931. Manganese in reduced state does not give color with *ortho*-tolidine, but when oxidized by chlorine to manganic state produces color causing high results in residual chlorine determinations. Following method is more accurate. Determine first apparent residual chlorine content with *ortho*-tolidine in usual way. Then boil a second sample for 5 minutes, or more (boiling off 25 cc. from 100 cc. sample), cool to room temperature, or slightly lower, and make up to original volume with distilled, or any other manganese-free water. Determine false residual chlorine by addition of *ortho*-tolidine. Subtract second reading from first to obtain the correct residual chlorine content. If a precipitate forms on boiling add more *ortho*-tolidine until it is dissolved. In FORMAN test, the unchlorinated sample is made strongly alkaline with caustic soda and oxidized by displacing the air in bottle above the sample with oxygen, then stoppering and shaking violently. Oxidized sample is neutralized, or slightly acidified, and *ortho*-tolidine added. Results thus obtained is subtracted from results obtained on chlorinated samples.—*C. C. Ruchhoft* (*Courtesy Chem. Abst.*).

Joint State and Federal Underground Water Survey. WALTER N. WHITE. Proc. Twelfth Texas Water Works Short School, 1930. A discussion of the various hydrological problems, together with the field methods used by the Survey, is given in this paper. A reflection of the increasing interest of the different states in their ground water problems is manifest by the action of the Federal Congress, which seeks to appropriate an increased addition of $234,000 for investigation of water resources. It is the policy of the Survey to use their funds in conjunction with matched State appropriations to pursue systematic investigations. The ground water investigation was begun in Texas September 1, 1929, under a $20,000 appropriation from the State Legislature for a coöperative State and Federal Survey. The United States Geological Survey, the State Board of Water Engineers, the State Department of Health, the State Bureau of Economic Geology, and the Agricultural and Mechanical College are all coöperating in the study. The studies which are being carried out in various counties of the State include: (1) Available quantity of underground water; (2) salt water leakage and infiltration; (3) sanitary conditions affecting underground water; (4) data on recharge, infiltration, flow, geology, etc. of various underground reservoirs.—*A. W. Blohm* (*Courtesy U. S. P. H. Eng. Abst.*).

Unusual Uses of Chlorine in a Water Department. R. W. KEHN. Proc. Eighth Annual Water Works School, University of Kansas, Lawrence, **2**: 86. A short summary of the use of chlorine in the sterilization of new water mains, distribution tanks, gravel from polluted river beds used in the construction of wells and the disinfection of ground water supplies when the ground around them becomes flooded. In a number of Kansas water supplies pollution existed in the supply from new water mains for from three to twelve months, the average time for new mains to clear themselves of pollution being six and one-half months. The procedure used for sterilizing new mains in New York City, Chicago and Indianapolis are stated briefly.—*A. W. Blohm* (*Courtesy U. S. P. H. Eng. Abst.*).

Administration of Swimming Pool Standards in Detroit. WM. J. CARY. American Jour. of Public Health and the Nation's Health, 20: 7, 727, July, 1930. During 1928 over 2,000,000 registrations were recorded for 40 pools. Supervision consists mainly of the following activities: control of the use and operation of the pools; an educational program to bring before the operators, instructors and bathers the essential principles of swimming pool sanitation; and supervision of the alteration of present pools and the construction of new ones. Regulations have been prepared governing operation of pools. Rating of pools is based upon bacterial results of water samples as these have been found to reflect fairly accurately the sanitary conditions and control of the bather.—*A. W. Blohm (Courtesy U. S. P. H. Eng. Abst.).*

Municipal Works of Johannesburg. E. H. WAUGH. Surveyor, 73. 2010, 125, August 1, 1930. Swimming pools: There are seven open air pools, varying in size from 100 by 150 feet to 75 by 100 feet, with several more projected. Rapid sand filtration is installed at each pool.—*A. W. Blohm (Courtesy U. S. P. H. Eng. Abst.).*

Municipal Swimming Pool at Hamilton (Ontario). E. H. DARLING. Canadian Engineer, 58: 10, 311, March 11, 1930. A detailed, illustrated description of a municipal swimming pool recently constructed in Hamilton. The pool is 75 feet long and 45 feet wide, the minimum depth being 3 feet and the maximum 10 feet 6 inches. Between the deep and shallow areas the floor is raised in two 9 inch steps to form a low wall 2 feet wide and 3 feet 6 inches below the surface. The floor of the deep area is a hollow inverted pyramid. The water capacity of the pool will be about 100,000 gallons. Provision has been made for filtering the pool water 3 times a day. The water is drawn off by means of a circulating pump through a hair strainer and forced through a pressure filter, the rate of filtration being about 3 gallons per square foot minute. Chlorine is added in the return line between the pool heater and the pool. The returned water is admitted to pool at each corner. The cost of the pool was $110,000.—*A. W. Blohm (Courtesy U. S. P. H. Eng. Abst.).*

Swimming Pool Supervision in Rhode Island. STEPHEN DEM. GAGE. Pub. Health News, Dept. of Health of the State of New Jersey, 15: 2–3, 46, January–February, 1930. The Rhode Island swimming pool law provides that after July 1, 1928, no swimming pool can be operated without a license from the Public Health Commission. The pool must be inspected at least once a year and chemical and bacterial analyses must be made at least twice each month. The Board of Commission may suspend and, after a hearing, revoke a license. The licenses are for one year and a fee is charged for each three months of operation or fraction thereof. A penalty is also provided for in the Act. Regulations were adopted by the Commission which are practically the same as those adopted by the Joint Committee of State Sanitary Engineers and the Public Health Engineering Section of the American Public Health Assoc.—*A. W. Blohm (Courtesy U. S. P. H. Eng. Abst.).*

Hereford's New Public Baths. Surveyor, 77: 1998, 545, May 9, 1930. New public baths at Hereford (Eng.) include first and second class slipper baths,

cloakrooms and lavatories, shower baths, collapsible dressing drooms, a 75- by 30-foot swimming pool and a laundry. The depth of the pool ranges from 3 to 7 feet. It is lined with white tiles, with black swimming lines and inset steps. The pool water is recirculated and repurified every four hours, the purification process consisting of straining, coagulation, rapid sand filtration, aeration and chlorination. After aeration it is passed through a calorifier and restored to the required temperature for bathing.—*A. W. Blohm (Courtesy U. S. P. H. Eng. Abst.).*

Outdoor Public Bathing Places. I. R. Riker. Public Health News, New Jersey Dept. of Health, 15: 2–3, 36, January–February, 1930. A recent survey of bathing places in the State of New Jersey revealed nearly 400 established places of which 65 are indoor pools and 54 are artificial outdoor pools. Standards for artificial pools have been adopted by the Joint Committee on Bathing Places of the American Public Health Assoc. and the Conference of State Sanitary Engineers in 1927. Due to practical difficulties, none have been adopted for bathing beaches. Regulations should be adopted to cover artificial pools at least. It is felt that with natural bathing places each situation must be dealt with separately depending on local conditions. Surveys are made occasionally and a list of what a survey should include is given. The degree of pollution of a river is controlled by the State Health Department and the streams are classified according to their use. The State Health Department requires that sewage discharged into the ocean be treated at least by sedimentation and chlorination and the outlet be at last 1,000 feet from the low water mark.—*A. W. Blohm (Courtesy U. S. P. H. Eng. Abst.).*

Operating a Public Swimming Pool. C. E. Barry. Canadian Engineer, 58: 8, 241, February 25, 1930. A detailed description of the design and operation of a small public swimming pool recently built at Ocean Falls, B. C. The pool is 25 feet wide by 60 feet long, the depth varying from 3 to 8 feet. Foot pools were provided at the entrances from the two dressing rooms through which the swimmers must pass before entering the pool. An innovation is the provision of a pool for small children near the shallow end of the main pool, the dimensions being 18 feet by 4 feet 9 inches. A depth of 12 inches of water at a temperature of 80 to 85°F. is maintained in the small pool by overflow. The pool water is treated with crystal alum, passed through pressure filters and chlorinated, the proper residual chlorine content being maintained by means of o-tolidine tests. Soda ash is added when required. A suction sweeper was provided for removing sediment from the bottom of the pool.—*A. W. Blohm (Courtesy U. S. P. H. Eng. Abst.).*

Engineers and Operators Inspection of Filters. Roger H. Chapin. City of Detroit, Dept. of Health, Swimming Pool Review, Series 4: 5, 1, May, 1930. Inspections of the filters should be made regularly to determine the cleanliness of the sand, presence of slimy deposits or balls of mud or hair. The efficiency of washing should also be determined from time to time. Among the causes of filter breakdown are to be noted: insufficient time of washing, insufficient volume of wash water, due to lack of pressure or to back pressure

from small sewer lines, infrequency of washing and binding due to mud, lint and hair.—*A. W. Blohm (Courtesy U. S. P. H. Eng. Abst.)*.

Reduction of Bacterial Content of the Detroit Swimming Pools. City of Detroit, Dept. of Health, Swimming Pool Review, Series 4: 1, 4, April, 1930. A steady reduction in the bacterial content of the Detroit swimming pools has been noted since 1925, although a rise in the summer months is to be noted in each year. The following steps are being taken to lower the summer increases in bacteria: (1) Check up on the efficiency of pool equipment; (2) increased numbers of inspections by the city health department; (3) increase in the number of pool operators and attendants; (4) increased use of cold water in the make up of pool water and (5) general educational program on the use and operation of swimming pools.—*A. W. Blohm (Courtesy U. S. P. H. Eng. Abst.)*.

Bacterial Analysis of Swimming Water. City of Detroit, Dept. of Health, Swimming Pool Review, Series 4: 6, 1, June, 1930. The Department of Health originally determined the bacterial content of swimming pool water from the total count on agar at 37°C. in 24 hours by plating 1.0 and 0.1 cc. amounts and the number of *B. coli* by planting 10.0, 1.0 and 0.1 cc. amounts in fermentation tubes, the gas formers subsequently being confirmed on Endo plates. In 1929 the planting of the 0.1 cc. portion in the fermentation tube test was discontinued, only 84 tubes out of a total of 18,392 having shown gas. In 1930 the planting of the 1.0 cc. portion was also discontinued only 308 tubes out of 23,055 having shown gas. At the present time the standard procedure for the examination of this water calls for the planting of 1.0 and 0.1 cc. portion on agar plates and the planting of five ten cubic centimeter amounts in lactose broth. Gas formers are confirmed on brilliant green bile.—*A. W. Blohm (Courtesy U. S. P. H. Eng. Abst.)*.

The Spa Problem and the Czechoslovak Spas. A. KOLINSKY. Trans. First International Congress of Sanitary Technique and Communal Hygiene. The author mentions the exhaustive influence of the stress and strain of modern life in our large cities and that physicians are becoming convinced that the best treatment for such ills is a cure in climatic resorts. Modern balneology tries to utilize the latest scientific discoveries in making our spas into centers of health both from the physical and from the moral point of view of the modern society. A satisfactory program should be based on scientific researches and marked out in detail, separately for each individual spa. Czechoslovakia is known for its richness in mineral springs. The well known Karlovy Vary (Karlsbad) and the largest spa of Jachymov are situated in Czechoslovakia. One of the most famous political economists has correctly pointed out some time ago that Czechoslovakia would certainly occupy the first place as "manufacturers" amongst all other countries, should it be possible to manufacture health.—*A. W. Blohm (Courtesy U. S. P. H. Eng. Abst.)*.

Annual Report of State Board of Health of Missouri, 1929. Weekly samples are gotten from all surface supplies, and four per year from ground water

supplies. A great deal of work is being done to promote safer water and sewage disposal in small communities. Twenty-six surveys were made. There are now 11 full-time inspectors in 11 counties with whom contacts are kept. The Division also has to do with sewerage and water supply of state institutions. Regulations were adopted concerning ice and bottled water.—*A. W. Blohm (Courtesy U. S. P. H. Eng. Abst.).*

Typhoid Drops to a New Low Rate. Public Health News, New Jersey State Dept. of Health, **15**: 7, 147, June, 1930. Further reduction in typhoid fever cases and deaths in New Jersey resulted in new low case and death rates in 1929. The 318 cases reported were 66 less than 1927, the previous low year. Deaths numbered 52. Customary expressions of these facts would be a case rate of 8.4 per 100,000 population in 1929 and a death rate of 1.3.—*A. W. Blohm (Courtesy U. S. P. H. Eng. Abst.).*

Flow through in Clarification Plants (Model Experiments). A. Hinderks. Der Bauingenieur, 1929, **35**: 618; Wass. u. Abwass., 1930, **26**: 316. Summary of Current Literature, **3**: 8, 264, August, 1930. "Experiments were carried out, at the instigation of the Emerschergenossenschaft, to explain the flow-through in different forms of sedimentation tanks. Turbulent and not streamline flow occurs in shallow sedimentation tanks. The flow-through in the interior of a clarification tank is determined by the mass action of the inflowing water. Eddies occur either at the beginning or end of the tank according to the method of introduction, while the chief settling region lies in the part of the tank free from eddies. When an eddy forms freely in the front part of the clarification tank and the clarified sewage runs off freely over a final weir, the true clarification space is shortened by an amount corresponding approximately to the length of the eddy and of the range of influence of the final weir. Experiments with different forms of clarification apparatus have shown that the direction of flow generally depends on the form of the apparatus. The velocity of the water is not greatly retarded by a narrowed section or by a deflecting wall; the water, after passing through the narrowest place, flows rapidly, with an almost undiminished velocity, into the wide section under strong lateral eddy formation."—*A. W. Blohm (Courtesy U. S. P. B. Eng. Abst.).*

Character of Ground Water in Eastern and Central Montana. Eugene S. Perry. Water Works Eng., **83**: 20, 1454, Sept. 24, 1930. The study of ground water occurrence in Eastern and Central Montana leads to the conclusions (1) that several pronounced water producing horizons exist and (2) that because of structural conditions, wherein locally mountain uplift has occurred, hydrostatic heads have been built up in various places. The Montana Bureau of Mines and Geology is of the opinion that flowing water wells can be obtained in localities where at present wells have not been drilled and where surface water is of poor quality.—*A. W. Blohm (Courtesy U. S. P. H. Eng. Abst.).*

New Water Supply at St. Petersburg. Charles F. Ruff. Water Works Eng., **84**: 21, 1487, October 21, 1931. During 1929, supply was too salty to be

palatable. New well supply was developed, consisting of 12 drilled wells averaging 300 feet deep. Principal feature of development was construction of 26-mile pipe line of 36-inch steel cylindrical pipe manufactured on the job by Lock Joint Pipe Company. Most of excavation was in sand and pipe-laying was difficult. Two interesting water crossings are described.—*Lewis V. Carpenter.*

A Reservoir with Unusual Features. STUART F. KNOX. Water Works Eng., 84: 21, 1483, October 21, 1931. Reservoir for White Plains, N. Y., is nearly trapezoidal in plan and fits into a ravine, so that quantities of concrete and masonry were a minimum. Capacity is 9,000,000 gallons, about one-half of which is below highest point on floor. Depth at full storage varies from 10.5 to 32.5 feet. Front wall is like a dam across the ravine. It is designed as horizontal slab supported by vertical buttresses at nine-foot centers, acting as cantilevers, bonded into footing under the wall.—*Lewis V. Carpenter.*

An Emergency Water Supply. D. M. TYLER. Water Works Eng., 84: 21, 1485, October 21, 1931. City of Elkins, W. Va., takes its supply from Tygarts Valley river which dried up during drought of 1930. Portable pumping station was established on Cheat river, 14 miles away. It was necessary to lay 3500 feet of 6-inch pipe; about half, through a railroad tunnel and remainder, in open ditches. It took about 6 weeks to get water in sufficient quantity to supply the town.—*Lewis V. Carpenter.*

85 Year Old Cast Iron Pipe Still in Use in Boston. ANON. Water Works Eng., 84: 20, 1430, October 7, 1931. Section of cast-iron pipe, near Frog Pond on Boston Common was uncovered September 30. Pipe was brought from Scotland and placed in service October 25, 1848. Former President of the United States, JOHN QUINCY ADAMS, and Mayor JOSHUAH QUINCY of Boston used the same shovel to throw the dirt on the pipe as was used by Mayor CURLEY of Boston to fill up the excavation. The band played the same music that marked the occasion 85 years ago, "Hail Columbia" and "Adams and Liberty."—*Lewis V. Carpenter.*

The Law of Water Works Construction. LEO T. PARKER. Water Works Eng., 84: 20, 1425, October 7, 1931. Courts in most states have held that contract should be given to lowest responsible bidder and discretion is required in determining which one is responsible. Cites one case where municipality awarded contract to bidder who was $10,000 higher than lowest bidder and court ruled that award was invalid, as municipality did not investigate thoroughly the responsibility of low bidder. Clerical mistake in bid submitted by contractor is entitled to consideration, if because of a mistake clearly apparent to city officials, bid does not comply strictly with advertised terms. If state law limits amount which municipality may expend on a contract and municipality awards contract in excess of this sum, courts have held such contract illegal. Generally speaking, party contending that contract should be construed according to unusual rules, or with meaning different from that it would ordinarily bear under the law, is bound to prove his assertions; if he fails to do

so, court will interpret contract in view of meaning which should have been intended by ordinarily prudent and reasonable persons. Under all conditions, contractor is expected by law to exercise care to safeguard his employees against injury and also to protect adjacent property. Several court cases on these subjects are cited. Several court decisions on responsibility of bonding companies are given.—*Lewis V. Carpenter.*

Many Unique Features in Ware River Water System. KARL R. KENNISON. Water Works Eng., **84**: 19, 1327, September 23, 1931. Metropolitan Water Commission went to Ware River for additional supply. Legislation limited diversion to so-called flood flows, that is, flow in excess of 85 m.g.d. No diversion is permitted from June 15 to October 15. Diversion dam prevents flow from entering control works until after 85-m.g.d. level has been reached. Flood flow is diverted by means of 9 siphon spillways varying in capacity from 60 to 550 second-feet under 9-foot head. Siphons are primed by series of float switches which automatically connect each siphon in turn to vacuum pipe system in building. Siphons discharge through nozzles, which discharge the water tangentially, against side of shaft 18 feet 6 inches in diameter, lined throughout with cast iron and 265 feet deep. Side plates are designed so that webs make continuous helical vanes which keep the water in rotatory motion. When flow increases to 450 second-feet, water level in tunnel rises and seals shaft, maintaining water-cushion at least 25 feet deep. Diversion is on 100 percent automatic basis.—*Lewis V. Carpenter.*

Slide Rule for Boiler Water Analysis. HAUPT. Gas- und Wasserfach, **74**: 15, 341–342, April 11, 1931. Soda number (Z) for non-corrosive water should lie between 400 and 2000, as given by formula,

$$Z = (2p - m)\,40 + \frac{(m - p)\,106}{4.5}$$

where p is figure obtained by titration with tenth normal hydrochloric acid using phenolphthalein and m, the figure using methyl orange. A slide rule for this calculation has been evolved and can be obtained from Koch, Huxhold, and Hannemann, Hamburg 30.—*W. G. Carey.*

The Test Pipe as a Method of Studying Biological and Chemical Deposits in Water Pipes. R. KOLKWITZ and E. BEGER. Gas- und Wasserfach, **74**: 12, 267–269, March 21, 1931. Test pipe is inserted as by-pass of main pipe and is connected by union joint and flanged joint; it contains inner pipe with vertical and horizontal slits to hold test plates of glass, wood, or metal (aluminum, iron, or zinc). Sludge trap is provided so that sludge as well as deposit on plates can be examined.—*W. G. Carey.*

The Waterworks at Ackerfähre on the Ruhr with Rapid Filter Plant and Seepage for Increasing the Ground Water Supply. H. KRING. Gas- und Wasserfach, **74**: 9, 193–199, February 28, 1931. Water from Ruhr, after screening, is passed through rapid filters to seepage basins containing sharp sand and gravel from whence it takes from 12 to 15 hours to reach intake wells, 52 in

number. As deposit in basins reduces efficiency of seepage, well shafts were sunk in basins and deposits removed by pumping from these wells.—*W. G. Carey.*

Operation of Elbe Waterworks and Preliminary Work for the Supply of Ground Water to Altona. LICHTHEIM. Gas- und Wasserfach, **74**: 11, 237–245, March 14, 1931. Electrical pumping with turbines has displaced steam, and rapid sand pre-filters have resulted in economy in sand washing and attendance in slow filters. An easily movable band conveyor transports sand from slow filters to wagons, so that a filter is cleaned in half a day instead of a day. A transportable chlorination apparatus is used in operation of slow sand filters. Aluminum sulphate is added in collecting well between slow and rapid filters. Owing to growth of Altona, wells have been sunk and now one-third of total supply is obtained therefrom and goes direct to clear water reservoir.—*W. G. Carey.*

The Formation of Artificial and Natural Protective Coatings in Water Pipes. L. W. HAASE. Gas- und Wasserfach, **74**: 24, 572–576, June 13, 1931. Polarisation, or formation of protective film of hydrogen, is caused by combination of hydroxyl ions with iron, but in presence of dissolved oxygen this hydrogen may be oxidised, leaving metal open to further attack. Oxygen may form with iron a protective layer of rust, especially if carbonates and sulphates are present in the water. In equilibrium waters, layers thus formed are protective, but in waters low in carbonate, or containing acid, rust coating alone is not protective. Lead pipes should be used only with waters containing carbonates and oxygen, but aggressive, or acid, waters can be treated for carbonate enrichment. Reactions between water and metal proceed more quickly when water is hot. Copper and tinned copper are satisfactory for hot, or cold, water; solvent action reaches an equilibrium, particularly if air is excluded.—*W. G. Carey.*

Sterilization of Drinking Water with Iodine. Boletin de la Sociedad de Fomento Fabril, 852–853, November, 1930; Water and Water Engineering, **33**: 388, 190, April 20, 1931. Iodine is applied as a highly diluted tincture, or as aqueous solution; concentration used is similar to that of chlorine; generally, one part per 100 million of water is sufficient for sterilization, and water contaminated with sewage is perfectly sterilized. Treatment is specially useful in mountainous districts where water is poor in mineral matter. Following formula was employed during war by French army: iodine, 0.3 gram; potassium iodide, 0.6 gram; water, 1000 cc.; 10 drops being added per litre of water.—*W. G. Carey.*

Some Microbes of Importance in Waterworks. C. A. H. VON W. KÜHR. Water en Gas, 259–262, December 26, 1930; Water and Water Engineering, **33**: 389, 239, May 20, 1931. *B. coli* is usually regarded as indicating fecal contamination. Test proposed uses glucose-phosphate-peptone gelatine plate with lacmoid indicator, *B. coli* giving characteristic red colonies in 48 hours, while *B. aërogenes* does not. *B. manganicus* removes manganese from dune

water, which has pH range 7.3 to 8.1, and manganese dioxide formed attracts further manganese. Life of sulphate-reducing bacteria is conditioned by (1) absence of air, (2) presence of assimilable organic compounds, and (3) presence of sulphates. These conditions are satisfied by Amsterdam dune water at depths of 39 to 150 feet in presence of peat: the resulting hydrogen sulphide causes energetic corrosion of pipes not protected with asphalt.—*W. G. Carey.*

Industrial Ultra-filtration and the Meta-filter. Anon. Quimica e Industria, 253–256, October, 1930; Water and Water Engineering, 33: 385, 46, January 20, 1931. Earlier types of ultra-filters were Chamberland filters impregnated with gelatine, or other colloid, and they completely separated colloidal matter in water etc. Nitrocellulose now gives excellent results as filtering material and is easily handled. Three types are in use, Chamberland, pressure, and funnel ultra-filters, and serve in bacteriology to render water bacteria-free. Owing to their relatively rapid filtration, they can be recommended for sterilizing large amounts of water for domestic supply. The meta-filter is composed of a large number of superposed perforated plates through which water is pumped under pressure. Water enters from below, passes through interstices between the plates and out through the perforations. Plates may be made of copper, tin, zinc, steel, celluloid, or wood.—*W. G. Carey.*

Annual Report for 1930 of the Laboratory for Water Purification at Mangarai, Batavia, Java, Dutch East Indies. Water and Water Engineering, 33: 392, 405, July 20, 1931. Report (in Dutch) describes experiments with a Buhring coal filter and with an ozone apparatus. Treatment with Chloramine Heyden, dechlorination with active carbon, and bacteriological research into pollution of ground waters resulting from infiltration from septic tank, are described.—*W. G. Carey.*

Water Purification by Precipitation and Coagulation. H. A. J. Pieters and W. J. de Kok. Chem. Weekblad, 28: 365, 1931; Chemistry and Industry, 50: 32, B. 744, August 7, 1931. Effects of alum, calcium hydroxide, barium chloride, etc. on clarification rate of loam suspensions, clay suspensions, and effluents from coal washing plants have been determined. Quantity of precipitant added, above a definite limit, does not influence rate of clearing. Starch acclerates settling when calcium hydroxide is the precipitant. Filtration through weathered spent oxide readily clarifies effluents, owing to action of electrolytes produced during weathering.—*W. G. Carey.*

Purification of Drinking Water with Norit Filters. H. L. Nattijsen. Water en Gas, 83, May 1, 1931; Water and Water Engineering, 33: 392, 405, July 20, 1931. The Netherlands Railways experimented with portable filters containing 750 grams of Norit (0.5 to 1 mm.) resting on a coarse porous slab, tests of raw and filtered water being made at intervals of about two weeks. Output and rate of filtration were irregular; iron was satisfactorily removed, and nitrate content diminished; but action on nitrites was less satisfactory;

oxidizable organic substances were removed tolerably satisfactorily, especially when present in considerable quantity.—*W. G. Carey.*

The Combination of Bacteria-Proof Filters with Katadyn. KONRICH. Gas- und Wasserfach, **74:** 15, 329–331, April 11, 1931. Water containing nutrient media and *B. coli* was filtered through Berkefeld candles containing Katadyn silver; no bacteria could be found in filtered water; while with control candle in use for same period bacteria were present in filtered water.—*W. G. Carey.*

Development of the Waterworks of Breslau. E. KIRCHNER. Gas- und Wasserfach, **74:** 23, 522–527, June 6, 1931. Description of recent improvements with plan of works, charts, and tables. Infiltration from river Oder gives variable iron content, which is dealt with by mixing ground water containing easily removed iron with the water containing organically combined iron and adding lime. Oder water for emergency use is chlorinated, treated with alum, and delivered in to ground water sedimentation tank. Capacity of pure water reservoir is more fully utilized by new pumping plant; but since supply is still insufficient for dry seasons, new waterworks is being designed.—*W. G. Carey.*

The Raw Water Measuring Plant of the City Water Works of Breslau. E. KIRCHNER. Gas- und Wasserfach, **74:** 23, 527–529, June 6, 1931. Woltman meters were unsatisfactory, owing to deposition of iron upon the blades, so that amount of water had to be deduced from number of pump revolutions. Flow is now satisfactorily measured over weirs. Illustration of the recording indicator for measuring flow is given.—*W. G. Carey.*

Graphical Integration in Hydraulic Problems. SAMUEL SHULITS. Journal Boston Society of Civil Engineers, **18:** 8, 287–300, October, 1931. Graphical integration, based upon methods treated by SCHOKLITSCH in his "Graphische Hydraulik" for the determination of the equalizing effect of lakes on flood control reservoirs and the evaluation of current meter measurements, is described. Use is made of the summation curve, which is the integral curve of the function.—*J. F. Pierce.*

Control of Microscopic Organisms in Public Water Supplies with Particular Reference to New York City. FRANK E. HALE. Journ. New England Water Works Association, **44:** 3, 361–385, September, 1930. Summarizes progress made in removing taste and odor from New York City's drinking water since GEORGE C. WHIPPLE in 1897 aided to control objectionable microorganisms, particularly *Asterionella*, in Mt. Pleasant Reservoir. Copper sulphate was recommended for growths, which had reached concentration of 10,000 to 20,000 areal standard units. Objections raised to $CuSO_4$ led to comparative study of death rates of New York City, using copper sulphate in addition to chlorine, and of Chicago and other cities, where chlorine alone was used. Instead of finding copper deleterious, remarkable decrease in deaths from cirrhosis of liver was observed in New York. Progress from earlier crude methods of applying copper sulphate by spraying and from rowboats to con-

tinuous dry and solution feeds is traced. *Synura*, *Uroglena*, and *Aphanizomenon* were controlled using 1 pound of $CuSO_4$ per million gallons of estimated flow. Marked improvement in quality of water was obtained by lowering point of draught. At Ashokan and Kensico reservoirs, aëration has not been particularly effective, although it has eliminated some taste and has served to disintegrate the colonies. Ordinary dosages of chlorine, 0.15 p.p.m., upon 700 units of *Tabellaria* liberated taste. Superchlorination was more effective, killing crustacea and eliminating taste.—*T. F. Donahue.*

The Wanaque Water Works Project. Arthur H. Pratt. Journ. New England Water Works Association, **44**: 3, 387–450, September, 1930. Project was undertaken by New Jersey Water Supply Commission to care for needs of municipalities in north Metropolitan Area of New Jersey, with present population of over two and a half millions and an estimated future population of 5 millions in 1960 according to figures of Committee of Regional Plan of New York and Environs. Run-off from catchment area of 94.4 square miles is impounded in Wanaque Reservoir which has storage of 29,600 m.g. and yield of 100 m.g.d., supplied to cities through aqueduct consisting mainly of twin 74-inch steel lock-bar pipe lines. Newark, Paterson, Kearney, Passaic, Clifton, Montclair, Bloomfield, Glen Ridge, and Elizabeth are served. Water is soft with little vegetable matter in solution and slight pollution. Aëration is practiced at Raymond Dam, the major project. Details are given of legal and engineering difficulties which had to be surmounted: supplies of half of the municipalities are privately owned. In addition to dams at south and southeast ends of reservoir, relocating of railroads and highways was involved. Operation during dry summer of 1929 showed adequate supply.—*T. F. Donahue.*

Water Supply and Dams in Japan. Allen Hazen. Journ. New England Water Works Association. **44**: 3, 451–57, September, 1930. During visit in November, 1929, author found conditions in Japan very favorable for water works, with abundant supply of water of excellent quality close at hand. Aqueducts to Tokyo and Yokohama are but 25 to 30 miles long. Beyond the low mountains of volcanic origin loom mountains of granite and other primitive rocks which give a soft water, usually free from turbidity and color. Careful husbanding of excreta for use as fertilizer reduces pollution of watersheds. Rainfall is high; the Tama River, with 200 square miles catchment area, supplying the 2,000,000 population of Tokyo with 50 gallons per capita per day without storage. Tokyo uses sand filtration without coagulation. Yokohama, Kyoto, and Osaka have filtration plants in use, or under construction. Dams of recent construction are of earth, or gravity masonry. There is one Ambursen dam on the island, but no arch dam.—*T. F. Donahue.*

Diesel Engine Pumping Equipment; Both Economical and Reliable. A. D. Couch. Journ. New England Water Works Association, **44**: 3, 458–467, September, 1930. Comparison of costs of installation and operation of steam, electric, and Diesel units for pumping in a small water works demonstrates practicability of using Diesel engines where cost of coal delivered is $6.50 per

ton, of current, $0.02 per kw-hr., and of fuel oil, $0.067 per gallon. Each installation, however, must be judged on its merits. Diesel engines have proven reliable over a long period, clean, economical, and quiet. Considerable noise may be eliminated, where step-up gearing is used, through proper housing of the gears.—*T. F. Donahue.*

Choosing Filtering Materials. Wm. E. Stanley. Civil Engineering, December, 1931, p. 1388. Selection of best type of filtering material, as between slag, crushed stone, gravel, and the like, involves controversial questions such as effect of roughness, effect of angular or rounded particles, and similar factors, on efficiency of operation, including ability of sewage filters to unload. The sodium sulfate soundness test has been set up as most practical determination of probable durability, and a test procedure has been developed. As yet there are insufficient data showing relation between results of soundness test and actual deterioration under service conditions, to fix definitely allowable limits by breaking down by soundness test. In general, satisfactory filtering material, as to durability, should have soundness rating of not less than 80. Principal objectives of the Committee tests have been the determination of the relationship of filtration and sand sizes, with reference to ability of filters to prevent passage of floc; length of filter runs, together with effect of temperature on length of such runs; and relation of sand sizes to filter washing, including optimum rates of applying wash water and effect of temperature on wash water rates. Secondary objectives are also enumerated.—*H. E. Babbitt.*

Coöperative Filter Sand Experiments. J. W. Armstrong. Civil Engineering. December, 1931, p. 1389. During 1928 and 1929 14 cities agreed to coöperate in conducting series of tests for purpose of determining best size and depth of filter sand. Baltimore was the only city doing any work during 1930. Work covered 8 different sizes of sand, ranging from very coarse to very fine. Interesting new facts were discovered that warranted extension of the investigations. Discoveries indicated that most of trouble from mud deposits is due to two things: use of filter sand that is too fine and too slow a rate in washing. Negotiations are now under way to enlist the coöperation of 16 additional cities in the investigations. In May, 1931, the Purification Division of the Am. Water Works Ass'n. appointed a Committee on Filtering Materials with duties similar to those of the Committee of the Am. Society of Civil Engineers. These Committees are now at work.—*H. E. Babbitt.*

Bacterial Samples from New Wells. C. W. Klassen. The Illinois Well Driller, January, 1932. Description of conditions resulting in well pollution and of nature of bacterial pollution. Non-technical explanation of methods of sampling and of bacteriological analyses. (*To be continued*).—*H. E. Babbitt.*

The 1930–1931 Drought and Its Effect Upon Public Water Supply. E. S. Tisdale. Am. Journ. Pub. Health, 21: 1203, November, 1931. The 1930 drought has dramatized as never before need of safe, adequate, palatable, public water supplies. The gigantic size of problem is difficult to realize, but

some conception can be gained by picturing the states of Maryland, Pennsylvania, Ohio, West Virginia, Virginia, and Kentucky, which embrace a territory of 200,000 square miles, and imagining water standing 2 feet deep over this entire territory. That is the amount of water which these states did not get in 1930. Article continues by studying problems created in each of states named, particularly during July–August, 1930. It closes with discussion by H. E. Moses.—*H. E. Babbitt.*

Hydraulics of Wells in Sand and Gravel Formations. H. O. Williams. The Johnson National Drillers Journal, January, 1932. Slope of ground water table required to cause flow is described and cause of draw-down is explained. It is pointed out that hydraulic gradient of surface of water entering well is a curve with increasing slope as well is approached, due to increasing velocity of flow. Methods for reducing gradient are discussed and advantages of the artificially-packed well are pointed out.—*H. E. Babbitt.*

The Disposal of Water Softening Plant Sludge at the Sewage Treatment Plant, Grand Rapids, Michigan. E. F. Eldredge. Bull. No. 40, Michigan Engineering Experiment Station, November, 1931. Water is softened at filtration plant by excess lime and recarbonation process. Average volume of water treated daily is 20 million gallons, with peak load of 30 million gallons. About 10 tons of lime are required to soften the water, producing 18 to 20 tons of sludge, on dry basis, consisting almost entirely of calcium carbonate, with a small amount of magnesium hydrate and no caustic alkalinity. Sludge is pumped to four 70-foot Dorr digesters at the sewage treatment plant, roofed for gas collection from mixture of sanitary sewage and lime sludge. Digested sludge is dried, ground, sacked, and used as low-grade fertilizer. Entire plant is controlled by small, well-equipped laboratory. Tests show the results satisfactory and indicate method to be applicable elsewhere, as there is no injury to biological processes.—*H. E. Babbitt.*

The Establishment of Water Rates: How to Go About It. R. E. McDonnell. Water Works Journal, published by Pittsburgh Equitable Meter Co., December, 1931. Rates are usually proposed by an engineer and approved by a board. For fair rates, proper fundamental considerations must be observed. These should include all of the factors making up the cost. These factors are listed. A higher rate, generally 50 per cent higher, is charged beyond city limits. Water rates in 14 western cities are stated for comparison. Effect of such factors as rate of consumption, large consumption, etc., on the rate are discussed. A minimum service charge of $1.00 per month is recommended. Charges for "free" water, public uses, sprinkler service, and other uses are discussed. Sources of income are analyzed in detail.—*H. E. Babbitt.*

A New Pipe Locator and Its Use in the Oklahoma City Water Department. Anon. Water Works Journal, published by Pittsburgh Equitable Meter Co., December, 1931. Electrical device for locating buried pipes, cables, gas lines, etc. Its operation and savings resulting therefrom are briefly described.—*H. E. Babbitt.*

Developing Wells with Compressed Air. ANON. Johnson National Drillers' Journal, November and December, 1931. Principles, equipment, and procedures involved in proper use of compressed air for well development are explained. There are two general methods of applying compressed air to increase flow of water into wells, or to develop new wells; (1) the back-washing method, and (2) the open-well, or surging method. The principle of the back-washing method is to force the water back out of well, through the screen, and into water-bearing vein by means of compressed air which is introduced into well through top of casing after it has been closed. Piping connections are so arranged that air is directed into well between drop-pipe and casing. Water is forced out through screen, agitating the sand and breaking down "bridges" of sand grains. When water has lowered to bottom of drop-pipe, it will go no farther, as air will escape up drop-pipe, thus making it impossible to air-log the water vein, a danger which must be carefully avoided in using this method. The open-well, or surging, method of development is more severe. Principle upon which it depends involves combination of surging and pumping. By sudden release of large volumes of air, strong surge is produced by virtue of resistance of water head, friction, and inertia. Pumping is done as with an ordinary air-lift. It is upon skilful application of this combination of surging and pumping that success of the work depends. It is essential that water rise high enough in well to submerge more than 60 percent of air line. Capacity of compressor can be estimated with accuracy, but inasmuch as field conditions are variable and losses great, it is practice to estimate compressor displacement as 0.75 cubic feet of air per gallon of water. In cases where maximum development is desired, there is no method which will surpass the combination of surge blocks, or plungers, used together with this open well, or surging, method of development with compressed air, provided requirements of submergence are met.—*H. E. Babbitt.*

Contamination of Mains by Jute Packing. C. H. SPAULDING. Am. Journ. of Public Health, 21; December, 1931, p. 1380. Discovery of *B. coli* in mains, wells, and pumps is not necessarily proof of contamination, because of large number of cases in which they have been found where pollution was doubtful. It therefore becomes highly desirable to know their origin when present. Writer has had many experiences of discovering *B. coli* in clean and sterilized mains after construction. Such behavior suggests a source of the organism which the chlorine cannot reach effectively. Suspicion turns to the jute packing in the bell and spigot joint. Laboratory tests of various jute packings are reported and following conclusions drawn. (1) Jute is a source of contamination in new mains. (2) Sanitary and unsanitary lots are on the market. (3) Chlorination of mains is an unsatisfactory method of sterilizing jute packing. (4) Jute should be shown to be free from coli-aerogenes group before being used for water pipe packing. References are given.—*H. E. Babbitt.*

National Aspects of the Drought. J. C. HOYT. Civil Engineering, 1; 1167, October, 1931. Facts upon which article is based were gathered through reports from the 33 district offices of U. S. Geological Survey, through rainfall

reports of Weather Bureau, and from other sources. Cause is unknown; although it is known that for a time there was a series of high-pressure areas scattered across the country and that low pressure did not develop in the atmosphere to bring rain. Later, when drought had broken in some regions, a stationary "high" over the Rocky Mountain and Great Basin areas forced the "lows" north or south, or up the Mississippi Valley, so that rainfall was diverted from a wide belt east of the Mississippi. Weather Bureau officials are unanimously agreed that sun-spots were not the cause. Until a cause is established, it will not be possible to predict rainfall, even for one year in advance. This places the science of water supply on purely empirical basis. It is certain that a drought as severe as that of 1930 can happen again, because 4 other droughts in past 50 years are comparable in extent, deficiency of rainfall, and continued heat. The fact that we cannot predict year of next major drought is added reason why immediate steps should be taken to insure water supplies against recurrence of conditions of 1930. Rainfall was deficient in 40 states and in 19 states records were broken. It was driest year on record. Observations of groundwater conditions are scanty, but levels observed in drought area establish beyond question the fact that groundwaters were seriously depleted in 1930 and will probably remain so throughout 1931. Water supplies, agriculture, navigation, irrigation, and water-power were all seriously affected. A condition that was emphasized by drought in 1930 is the wide variation between unit run-off in different areas. Over long periods, groundwater discharge could be studied directly, without rainfall to obscure the results. As many of the drought problems which affect the engineering profession have continued through 1931, engineers interested in water works planning will have the opportunity to obtain valuable information, which may stand for a long time as marking a low point on which future estimates can be based.—*H. E. Babbitt.*

The New Water Purification Plant at Kansas City, Missouri. E. W. Bachrach. Water Works Journal, October, 1931, published by Pittsburgh Equitable Meter Co. Complete description of 100,000,000-gallon plant, including three illustrations.—*H. E. Babbitt.*

Byzantine Aqueduct Still in Use. W. E. Smith. Civil Engineering, 1: 1249, November, 1931. Well-illustrated account of ancient aqueducts built during period of Justinian, 550 A.D., and still in perfect repair and in use for present water supply of Istanbul.—*H. E. Babbitt.*

Under-Reamers for Water Well Drilling. Anon. Johnson National Drillers' Journal, October, 1931. Under-reamer is device having two or three cutters which expand when reamer has passed out of lower end of casing and which contract again when being pulled up into casing. Use of reamer is described, as are the various devices on the market. Results obtained are described.—*H. E. Babbitt.*

Construction of Gravel-Packed Wells. M. Ebert. The Illinois Well Driller, August, 1931. The major equipment for making gravel-packed well consists of

rotary drills, a proper hoist, a water pump, and, perhaps, an orange-peel bucket. Construction of a well is described by following steps actually taken in construction of a particular well for which log is given. Methods of overcoming difficulties during construction are described.—*H. E. Babbitt.*

Limestone Wells in Illinois. L. E. WORKMAN. The Illinois Well Driller, September, October, November, 1931. Many difficulties not encountered in other formations are common to limestone wells, particularly encountering of caverns. Crooked holes frequently occur in limestone. Wells must be protected from contamination. Occasionally oil is encountered.—*H. E. Babbitt.*

Colorado River Aqueduct. Western Construction News, 6: 20, 542–544. October 25, 1931. Brief notes with map and profile of tentative location of aqueduct and main distribution lines.—*Geo. C. Bunker.*

Weiser Removes Tastes from Water Supply. H. J. ROSSON. Western Construction News, 6: 20, 545–546, October 25, 1931. Super-chlorination-activated carbon treatment is most effective method for removing tastes and odors caused by algae in Snake river water at Weiser rapid sand filtration plant.—*Geo. C. Bunker.*

Water Works for Boulder City, Nevada. BURTON LOWTHER. Western Construction News, 6: 20, 547–550, October 25, 1931. Three centrifugal pumps set on hoist-operated steel car will pump water from Colorado river, 1 mile downstream from Hoover dam site, at any stage between el. 643 and el. 683 feet through 10-inch steel pipe to pre-sedimentation clarifier at el. 742.63 feet. Clarified water will be lifted 986 feet to pumping plant No. 2 and from latter to water treatment plant 812 feet higher through steel pipes. All latest improvements in excess lime-soda ash method of softening are incorporated in plant. Filtered water will be lifted about 130 feet to a 2 m.g. distribution reservoir.—*Geo. C. Bunker.*

Hetch Hetchy 471 Mile San Joaquin Valley Pipe-Line. Western Construction News, 6: 20, 550–551, October 25, 1931. Construction details concerning 56-, 58-, 62-, and 66-inch electric-welded steel pipe in 30-foot lengths.—*Geo. C. Bunker.*

Sacramento Filtration Plant Enlargement. HARRY N. JENKS. Western Construction News, 6: 20, 552, October 25, 1931. Designed to increase capacity of pre-treatment units of municipal filtration plant to 64 m.g.d. and to provide improved means of operation.—*Geo. C. Bunker.*

The East Bay Municipal Utility District. F. W. HANNA. Western Construction News, 6: 20, 553–554, October 25, 1931. Discussion of basic causes for success of this district.—*Geo. C. Bunker.*

Green River Supply Line, Tacoma. Western Construction News, 6: 20, 554, October 25, 1931. Notes on reconstruction of 41 miles of continuous-stave

wood pipe to increase capacity of supply line from 42 to 57 m.g.d. Work started in 1924 and is to be completed in 1940.—*Geo. C. Bunker.*

Fort Lewis Swimming Pool. HOWARD F. CLARK. Western Construction News, **6**: 20, 555–557, October 25, 1931. Description of difficulties and of construction details in building pool in an abandoned hotel basement.—*Geo. C. Bunker.*

Albuquerque Builds Large Swimming Pool. J. D. HOLMES. Western Construction News, **6**: 20, 557–558, October 25, 1931. Conversion of city dumping ground into pool 4000 feet long and 350 feet wide, with maximum depth of 15 feet and capacity for 7000 persons at one time.—*Geo. C. Bunker.*

Water Works Improvements at Grant's Pass. JOHN W. CUNNINGHAM. Western Construction News, **6**: 20, 561–565, October 25, 1931. Municipality bought waterworks from private company and reconstructed it to include new rapid sand filter plant of 2.25 m.g.d., pumping station, enlarged reservoirs, and improved distribution system. Latter is 100 percent metered and only copper service pipes are used. Financial comparison of private and public ownership given. Excellent operating diagram of filtration plant.—*Geo. C. Bunker.*

Newark-San Lorenzo Pipe-Line for San Francisco. Western Construction News, **6**: 20, 567–569, October 25, 1931. Construction of 13-mile line of 36- and 44-inch electric-welded steel pipe in period of 87 days, or 108 days from award of contract, to furnish emergency supply to San Francisco from Mokelumne river supply project of East Bay Municipal Utility District. Pipe is laid above ground, one section of 3000 feet and all road crossings excepted. Two 30-foot sections of pipe were welded together at shop, to reduce number of field joints and expedite hauling. Cost of pipe alone was $648,867. Pumping station with capacity of 40 m.g.d. was built by San Francisco Water Department.—*Geo. C. Bunker.*

Abernathy Reservoir for San Jose. B. H. SKILLINGS. Western Construction News, **6**: 20, 570, October 25, 1931. Construction details of 1-m.g., circular, covered, reinforced concrete reservoir for water works of San Jose, California. —*Geo. C. Bunker.*

Santa Cruz Lays 20-Inch Pipe Connection. R. S. TAIT. Western Construction News, **6**: 23, 644, December 10, 1931. Brief history of water works of Santa Cruz, California. A line of 20-in. deLavaud class 150 c.i. pipe, 7900 ft. long, was laid between river pumping station and Bay St. distribution reservoir to deliver 6 m.g.d. at 90 pounds pressure. Total cost was $42,669 all of which will be taken from water department earnings.—*Geo. C. Bunker.*

Machine Excavation at 40 Cents a Yard; Hand Excavation at $1.18 a Yard. PAUL MONTGOMERY. Contractors' and Engineers' Monthly, **23**: 4, 66–67, October, 1931. Details of construction of 10-m.g., covered, reinforced concrete reservoir for water department of Topeka, Kansas. To relieve unem-

ployment it was specified that one-half of 22,000 cubic yards of excavation be done by hand; with result indicated in title. Pre-heated concrete was poured with outside temperature 6 degrees above zero and held at 80 degrees under canvas until danger of freezing was past. Cost was reduced and better results obtained by an admixture to cement. Standardized round metal forms were used for roof column supports; wall forms were made in uniform movable sections. Department's surplus funds of approximately $160,000 were utilized to build reservoir.—*Geo. C. Bunker.*

Additional Water Supplies for Cities. RAYMOND A. HILL. Western City, 7: 9, 17–19, September, 1931. Correct solution of problem of additional water supply for municipality must include analysis of need for such water, availability of proposed new supply, cost of its development, and quality of the water.—*Geo C. Bunker.*

Rainfall and Stream Run-off in Southern California Since 1769. Western City, 7: 9, 19–20, September, 1931. Summary of conclusions in report prepared by H. B. LYNCH for Metropolitan Water District, Los Angeles.—*Geo. C. Bunker.*

Water Problems in Honlulu, Hawaii. J. F. KUNESH. Western City, 7: 10, 13–17, October, 1931. Ninety percent of supply is obtained from three of the four isopiezic artesian valleys, from which water is pumped into high- and low-pressure distribution systems, each with its equalizing storage reservoir. From these water is boosted into higher reservoirs, to supply residential sections. Less than 10 percent of total supply comes from springs and tunnels. Quality of the mountain water has never been satisfactory and funds have been appropriated to build initial unit of filtration plant with capacity of 10 m.g.d. to purify water from Nuuanu stream. Due to unusual permeability and precipitous topography of the volcanic formation, reservoir storage is extremely difficult and largest reservoir (500 m.g. capacity) has been found extremely leaky. $250,000 has been appropriated to rebuild dam. Approximately $5,000,000 has been appropriated, and, up to date, about 80 percent spent, during last 6 years, on improvements of city's water works. Conservation of 11 m.g.d. has been gradually effected during last 6 years and unaccounted-for water reduced to 25 percent. Principle of artesian balance, believed to be applicable in California and other Pacific Coast states, is explained —*Geo. C. Bunker.*

Dividends from Water Purification at Sacramento. HARRY N. JENKS. Western City, 7: 10, 19–23, October, 1931. Existing plant was placed in operation in January, 1924, to purify Sacramento river water. Due to continually increasing demand, city being practically unmetered, coupled with crippling effects of certain structural deficiencies, a thoroughly palatable supply has not been furnished during critical summer seasons. As a result, opinion in city has been divided, some favoring new supply of mountain water, and others, provision of added filtration plant capacity, involving design and construction of new pre-treatment works along most advanced lines, to eliminate periodic

summer taste. In March, 1931, bond issue of $480,000 for additional plant capacity was approved by large majority. New pre-treatment works will bring capacity of plant up to 64 m.g.d. New works provide same general sequence of treatment as in original plant, but provision is made for application of the latest discoveries in fields of coagulation and taste elimination. Among notable features of new works is shallow sedimentation basin design, which is definitely related to factor of superficial area rather than detention period. During June, July, and August, 1931, daily per capita consumption ranged from maximum of 378 to minimum of 246 gallons, with average of 324; daily consumption in m.g. ranged from maximum of 35.5 to minimum of 23.1, with average of 30.4; and average maximum hourly rate was 45 m.g.d. Description of original plant is given and summary of laboratory analyses for year 1930.—*Geo. C. Bunker.*

Boise's Unique Hot Water System. Western City, 7: 10, 23–24, October, 1931. The Natatorium Company supplies natural hot water, with unvarying temperature of 170°F., from wells that have been used for 41 years, to a swimming pool, to 213 consumers for heating purposes, and to 75 consumers for domestic purposes. To replace corroded mains, 8,514 feet of 10-inch deLavaud cast iron pipe with Anthony joints were recently laid. Water is very corrosive, turbulent action of accompanying steam being held accountable. Difficulty is experienced in metering. Chemical analysis is given.—*Geo. C. Bunker.*

Chlorine Control of Certain Algae Growths in Los Angeles Reservoir. Carl Wilson. Western City, 7: 10, 25–28, October, 1931. Growths of protococcus in Ascot and Silver Lake reservoirs were not destroyed by application of 10 p.p.m. of copper sulphate. As result of complaints from consumers, Ascot reservoir was removed from service and roofed over an area of 7 acres at cost of $150,000. Near relationship of protococci to bacteria led to chlorination being given a trial and found completely effective. Calcium hypochlorite was used in first tests, but afterwards the more convenient liquid chlorine, with equally successful results. A self-propelled barge, or chlorine boat, was developed for applying sufficient chlorine to give dosage of one-third of one p.p.m. to depth of 9 feet over area of 100 acres, or to 300 m.g., in period not to exceed 8 hours. Detailed description of boat, with a section showing all the equipment, is furnished.—*Geo. C. Bunker.*

Preliminary Work Started on World's Greatest Water Supply Project. Western City, 7: 10, 28–29, October, 1931. Magnitude of Colorado River aqueduct is indicated by following mileages: open canals, 57.8; covered conduit, 96.1; tunnels, 110.8; shafts, 0.6; concrete siphons, 38.4; steel siphons, 0.2; steel pipe, concrete pipe, 31.1; and cast iron pipe, 0.8. Building roads is first and most urgent job and will be pushed as rapidly as funds can be made available. Before camps can be established, or construction work started, supply of potable water must be provided all along the line. The two principal long-time units are the tunnels under San Jacinto and Granite mountains. It is estimated that from 5 to 6 years will be required to make these bores. Present popula-

tion of 13 cities in Metropolitan Water District is 1,665,796 (1930 census).—*Geo. C. Bunker.*

Metering Practice: Results at Lewiston, Idaho. Western City, 7: 10, 32 and 47, October, 1931. Every meter is tested and adjusted to register within limits of 2 percent slow to 1 percent fast on three streams. Maintenance cost per meter in service during past year has been $0.25. Performance sheet of each individual meter is kept. Meters are read monthly and collections made quarterly. Standard meter setting consists of circular concrete box, 42 inches deep and 18 inches in diameter, patent locking metal top, and meter grips or yoke.—*Geo. C. Bunker.*

Denver Plans Its Water Supply System To Meet Future Demands. L. W. Marshall. Western City, 7: 10, 33–34, October, 1931. Present system is valued at $23,000,000 and consists of 825 miles of supply conduits and water mains, 4180 fire hydrants, and 68,187 services. Supply is derived from South Platte river and its tributaries, Bear Creek and Cherry Creek. There are four impounding reservoirs. Purification is effected by infiltration galleries, a slow sand filter, and rapid sand filters. Present supply is estimated to be ample for population of 375,000. Average daily consumption per capita has risen from 183 gallons in 1918 to 208 in 1930. Cost of operating is less than it was in 1924. With 3 percent increase in earnings, Board has paid operating and maintenance costs, made necessary replacements, and set aside $200,000 annually toward development of future supply. In addition, Board has refunded $460,000 of water bonds. Construction of Eleven Mile Canyon Dam, to impound additional 30,000 acre-feet, at estimated cost of $1,250,000, is now under way. Completion of dam is expected by June 30, 1932. Board is engaged in preliminary work on four major projects which contemplate using the pioneer bore of the Moffat tunnel. Lining has been extended for 4084 feet of approximately 6 miles of tunnel. Steel cylinder being run through bore is encased in 18 inches of concrete. The four projects will add 100,000 acre-feet to the water supply at estimated cost of $5,848,000. Plan of Board includes use of Blue River, through 24-mile tunnel, in distant future, to obtain additional 250,000 acre-feet.—*Geo. C. Bunker.*

Necessity for Roofs on Service Reservoirs. P. Diederich. Western City, 7: 11, 30–32, November, 1931. Interesting account of removal of roof over 15-m.g. service reservoir in Glendale, California, by city council, against recommendations of city manager and of superintendent, with result that growth of protococcus rendered water unfit for use. To keep growth down, from 0.2 to 0.3 p.p.m. of residual chlorine would have to be maintained all the time in reservoir. Council soon obtained a good insight as to public's feeling relative to roof removal episode and consequent condition of water served to consumers; but they could not decide on type of roof with which to re-cover reservoir. Temporary expedient adopted was to build wall 10½ feet high across reservoir and roof the southerly area, thus giving about 2.5 m.g. storage which can be utilized during reconstruction of whatever type of roof may eventually be decided on. Council's experiment has cost about $24,000 to date and the

much needed storage has not yet been replaced in service. Experiences leading to covering of reservoirs in other cities are given.—*Geo. C. Bunker.*

Water Distribution Systems and Public Fire Protection. MICHAEL MULLIGAN. Western City, **7**: 11, 35–39, November, 1931. Following subjects are discussed: determination of adequate supply; cross-connections; gravity and direct pressure systems; distributing reservoirs; storage requirements; capacity of pumps; elevated storage; pressure in system; hydrants; materials for mains; length of mains; spacing of gate valves; and records.—*Geo. C. Bunker.*

The Typhoid Season. Illinois Health Messenger, **3**: 13, 49, July 1, 1931. Among the 7,769,000 people in Illinois, between July 1 and November 1, 1930, about 700 contracted typhoid fever. About 275 of these lived in cities of 10,000 or more inhabitants, the other 425 living in small communities and rural districts. Hot weather and an empty stomach at time of infection favor onset of typhoid fever. In 1930, death rate from typhoid fever in cities of Illinois with more than 10,000 people each was 1.2 per 100,000. In remainder of state, it was 3.2.—*G. C. Houser.*

What Is Pure Water? H. W. CLARK. The Commonhealth (Mass. Dept. of Pub. Health), **18**: 2, 67, April–May–June, 1931. At the present time 96 percent of people in Massachusetts take water from, or have access to, public water supplies. No direct taking from a badly polluted river is made except by one city and this supply is rendered safe by filtration and chlorine treatment. A number of municipal ground-water supplies in the state are filtered, not to remove bacteria and increase their safety, but to remove iron and manganese. An entirely satisfactory water for domestic use should be clear, practically colorless, tasteless or nearly so; free from organic and mineral matter showing present or past pollution, low in bacteria, and absolutely free from all disease germs.—*G. C. Houser.*

Importance of the Public Water Supply. A. D. WESTON. The Commonhealth (Mass. Dept. of Pub. Health), **18**: 2, 69, April–May–June, 1931. At the present time 236 of the 355 cities and towns in Massachusetts obtain water wholly, or in part, from public works, and over 97 percent of total population of the state is included in cities and towns having such works. The number of deaths from typhoid fever in 1885 in the state was about 768, or 40 per 100,000 population. Number of deaths from this disease in 1929 was 42 (a rate of 1 per 100,000), a decrease in death rate of about 97 percent since 1885. In Massachusetts water of most public supplies is of excellent quality for manufacturing purposes, and for that reason large number of tanneries, bleacheries, paper mills, and textile industries have been established in the state.—*G. C. Houser.*

Rural School Wells. Illinois Health Messenger, **3**: 9, 35, May 1, 1931. Project to promote safety of rural school water supplies was started a few years ago in Illinois. To date 22 counties have undertaken rural school well surveys. In these counties, which include 3,185 schools, there have been 1,275 school water supplies inspected by local persons, 605 school supplies judged as satis-

factory by information from local inspectors, 260 school supplies inspected by state sanitary engineers and 103 Safe Water Certificates issued to schools.—*G. C. Houser.*

The Sanitary Code of West Virginia: Water. Quarterly Bulletin, W. Va. State Dept. of Health, 18: 2, 37, April, 1931. Regulations comprising sanitary code of West Virginia became effective April 1, 1931. Following items are included: testing drinking water for quality and healthfulness; making necessary tests and keeping records; requiring competent filter operators and superintendents of filtration; bathing in streams above water supply intakes; bottled waters; certain cross-connections between water supplies not permitted; permissible arrangements where dual supplies are used; non-potable water to be rendered unavailable for drinking; reporting changes in public water supply; and ice manufacture and sale.—*G. C. Houser.*

Iodine Found in Nature. C. H. Green. Health Bulletin (N. C. State Bd. of Health), 46: 4, 11, April, 1931. In parts of Michigan and Minnesota where iodine content of drinking water and of local foods is extremely low, as many as 70 percent of high-school girls have enlarged thyroids. Analysis shows that drinking water of the South and Atlantic Coast states contains from 23 to 18,470 parts of iodine per hundred billion against 1 to 20 parts in waters of the North and Northwest. An iodine content of less than 22 is considered iodine poor. Connection between goiter and drinking water goes far back into antiquity. Pliny and Vitruvius mention "goiter wells," as certain rivers and wells were supposed to be goiter producing.—*G. C. Houser.*

Emergency Drought Bulletin No. 4. Monthly Bulletin, Ind. State Bd. of Health, 34: 3, 231, March, 1931. Actual shortage of water supply, such as exists in portions of souhern Indiana, presents grave problem. Attention is called to more extreme dangers likely to accompany breaking of drought. With deficiency of precipitation of 40 to 60 percent, it is not unreasonable to expect abnormal amount of rainfall during spring rains. Directions for treating water with chloride of lime are as follows: Take 3 tablespoons of chloride of lime and mix with one pint of water. Use one tablespoonful of this solution to 15 gallons of the water to be treated or 36 drops to one gallon.—*G. C. Houser.*

Problems of Water Supply Common to Communities on Ohio River. F. H. Waring. Monthly Bulletin, Ind. State Bd. of Health, 34: 3,236, March, 1931. By reason of long continued drought characteristic taste was acquired by Ohio River, described as musty, moldy, or burnt leather, and commonly referred to as "river taste." Employment of excess lime served greatly to minimize river taste. Potassium permanganate was employed at one plant successfully for 3 days. Experience with continuous activated-carbon treatments during drought period has revealed that water so treated is free from river taste.—*G. C. Houser.*

Report of a Survey of School and Other Semi-public Water Supplies in Clark County, Indiana. Monthly Bulletin, Ind. State Bd. of Health, 34: 4, 53, April,

1931. Most of Clark County is supplied with drinking water from shallow dug wells or springs. Dependence of large number of schools upon sources of water supply not under control of school authorities is outstanding fact brought to light. Of 24 supplies used by schools, but not located on school property, only 2 were satisfactory. Of 21 supplies located on school property, 11 were found to be satisfactory, insofar as bacteriological quality was concerned.—*G. C. Houser.*

Unlicensed Operator Pumps Sewage into Water Main. Public Health News (N. J. State Depart. of Health), **16**: 5–6, 115, April–May, 1931. Inexperience was probable reason why a new sewage plant operator recently, in order to prime a sewage pump, connected discharge end to a water main and pumped a quantity of sludge into borough water system. Fortunately, it was winter and most of the dwellings along contaminated main were summer cottages and were closed. Operator did not hold license as required by law.—*G. C. Houser.*

Public Water Supplies in Virginia. RICHARD MESSER, A. WAGNER, H. W. SNIDOW and C. F. BINGHAM. Va. Health Bulletin, **23**: 4, 3, April, 1931. Norfolk and Petersburg were first municipalities in Virginia to have water filtration plants, construction of both having been started in 1898. Newport News was first city in Va. to start chlorination. This was in 1910. In 1930, 39.9 percent of population of state was served by public water supplies, 28.0 percent being supplied with filtered and chlorinated water, 6.5 percent with water that is chlorinated only, and 1.9 percent with water that is filtered only. During recent years pre-chlorination has been used advantageously in connection with treatment of colored water at Newport News, Big Bethel, and Norfolk. Aëration after filtration is practiced at Richmond, Lynchburg, Roanoke, and Covington. There are several municipal iron-removal plants in Va., notably those at Coeburn and Wise. So far only one municipality, Dublin, has a water softening plant. Data are given on each water supply in state, including those supplying incorporated cities and towns, colleges, institutions, and other communities.—*G. C. Houser.*

Drought Relief. Pennsylvania's Health, **9**: 3, 32, May–June, 1931. A year has elapsed since first indications of drought appeared in Pennsylvania; the longest unbroken stretch of deficiency in rainfall recorded by weather bureau. Federal government allocated $30,000 to Pennsylvania Department of Health for period covering March 1 to June 30, for relief measures. Problem is prevention of typhoid fever. During the four fall months, increase of more than 400 cases of rural typhoid was directly traceable to drought conditions. Work of 5 mobile laboratories will be devoted to existing typhoid and prevention of further cases by protecting public and private water supplies.—*G. C. Houser.*

Sanitary Engineering News Items. Monthly Bulletin, Ind. State Bd. of Health, **34**: 5, 73, May, 1931.—Use of powdered activated carbon for taste control has been inaugurated at the Anderson, Ind., water filtration plant. Carbon is applied to settled water by dry feed equipment, and is strained out on filters. Indianapolis Water Company has erected an elevated storage tank of

1.5 m.g. capacity in Irvington district. Last of Indiana Calumet district by-product coke plants to practice phenol recovery, or disposal, Youngstown Sheet and Tube Company at East Chicago, placed in operation about May 15 works for recovery of phenol from plant waste. Construction is under way on new water supply for Sellersburg. Contracts have been awarded for construction of an elevated storage tank by Valparaiso water dept., and construction is under way on a reservoir on Rogers Hill in Bloomington.—*G. C. Houser.*

What Price Typhoid? MonthlyReport of Board of Health, Paterson, N. J., July, 1931. Distressing and expensive epidemic of typhoid fever, involving 248 cases and 25 deaths, struck city of Olean, N. Y., a short time ago. It was caused by break in water suction line where it crossed the Allegheny River, with result that, for a short time, city was drinking considerable amount of its own sewage. To provide for cost of medical care and funeral expenses and to settle damage suits, State Legislature authorized loan of $450,000. At last report, nearly all this money had been spent and there were still 24 unpaid claims. A million dollars total actual financial loss is probably not too high a figure.—*G. C. Houser.*

Public Water Supplies in West Virginia. E. S. TISDALE. Quarterly Bulletin, W. Va. State Dept. of Health, 18: 3, 3, July, 1931. Typhoid death rate in West Virginia cities compares favorably with that of cities in adjoining states of Ohio, Pennsylvania, Maryland, and Virginia. However, in the mining and lumber camps and rural areas much work lies ahead. Death rate last year for the entire state, two-thirds of which is of a rural nature, was 12.1. Data are given on each public water supply in state.—*G. C. Houser.*

Raritan Valley Survey Begun. Public Health News (N. J. State Dept. of Health), 16: 9, 188, August, 1931. Sanitary survey of Raritan River and tributaries between Town of Raritan and Raritan Bay, for which New Jersey legislature made special appropriation, was started by State Department of Health on July 1. On July 7 department passed a resolution, citing pollution of river, bay, and tributaries with raw domestic sewage and with insufficiently treated sewage from disposal plants and notifying 14 municipalities to cease such pollution before October 13, 1931.—*G. C. Houser.*

Health Legislation. Illinois Health Messenger, 3: 15, 58, August 1, 1931.—Illinois legislature in 1931 authorized State Department of Public Health to act in supervisory capacity relative to sanitary quality and adequacy of proposed and existing public water supplies, and water treatment and purification works, and to prepare and enforce rules and regulations relative to installation and operation of public water works so that public water supplies will be of satisfactory sanitary and mineral qualities for drinking and general domestic use; to determine standards of purity of drinking water; and to prepare with assistance of State Geological Survey and enforce rules and regulations relative to filling, or sealing, of abandoned water wells and holes for disposal of drainage in order to protect ground water against contamination. Other legislation added to the power of sanitary district boards of trustees authority

for constructing dams across streams where this action will promote public health.—*G. C. Houser.*

Sanitary Engineering News Items. Monthly Bulletin, Ind. State Board of Health, **34**: 9, 136, September, 1931. New public water supply system is under construction in Cloverdale, Ind., as direct outcome of typhoid fever epidemic which occurred early in September. Pollution of Little Calumet River and its major tributaries has been investigated by Department of Sanitary Engineering. Report of investigation of public water supply of Anderson, Ind., recommends development and extension of White River filter plant. Contracts have been awarded for construction of iron removal and softening plant for water department of Peru, Ind.; treatment will include aëration, sedimentation, rapid sand filtration, and chlorination. Plans and specifications have been approved for construction of modern rapid sand filtration plant for Paoli, Ind., to replace present pressure filters. Plans have been approved for construction of filtration plant for Petersburg, Ind., present supply being taken from White River without treatment.—*G. C. Houser.*

Problems of Richmond's Water Purification Plant. M. C. Smith. Virginia Municipal Review, **8**: 9, 94, September, 1931. Rated capacity of present filter plant is 30 m.g.d., each of 10 filter units having 1,078 square feet area. Settling basins contain approximately 150 m.g. and coagulating basins are of approximately 15 m.g. capacity. Average daily consumption in 1929 was 19.3 m.g. Great difficulty has been encountered because of presence of very persistent trade wastes, principally from paper mills located on upper stretches of James River. Raw-water analyses for one week averaged color, 100; oxygen consumed, 25; alkalinity, 85. Alum is only coagulant used, as much as six grains per gallon often being required.—*G. C. Houser.*

Determination of Dissolved Carbon in Sewage. H. Bach. Z. anal. Chem., **85**: 161–70, 1931; Chem. Abst., **25**: 5945, November 20, 1931. Cf. F. W. Mohlman and G. P. Edwards, this Journal, **23**: 2189, December, 1931. To determine dissolved organic material in sewage, following method for determining carbon is recommended. To from 100 to 150 cc. of filtered water add 10 cc. 9 N sulfuric acid and boil 30 minutes under reflux condenser to decompose any carbonates present. Neutralize with 10 per cent sodium hydroxide and add 15 cc. in excess. Add 1 gram potassium permanganate and 4 drops 1 percent platinic chloride solution. Boil another half hour to oxidize all organic material to sodium carbonate, continuing, if necessary, until ammonia is no longer evolved. Insert in flask a stopper carrying a potassium hydroxide tube through which air can enter flask, a long funnel tube through which acid can be added, and a reflux condenser through which gas can be led to 10-bulb Meyer tube containing from 0.8 to 0.9 gram sodium hydroxide in 25 cc. boiled water. If sewage is rich in chlorides, insert small wash bottle containing 10 percent stannous chloride between condenser and Meyer tube. By means of aspirator connected to upper end of Meyer tube, draw air through solution for about 15 minutes, then render liquid in flask distinctly acid with 9 N sulfuric acid and draw all carbon dioxide over into Meyer tube. Finally transfer contents of Meyer tube to an

Erlenmeyer flask, add a little phenolphthalein solution and 0.1 N barium chloride solution until all carbonate is precipitated. Neutralize exactly, add measured volume of hydrochloric acid to decompose the barium carbonate and titrate excess with 0.1 N sodium hydroxide.—*R. E. Thompson.*

Experiments on the Importance of Protozoa in the Natural Purification of Water. K. KYRIASIDES. Ztschr. f. Hyg. u. Infektionskr., 1931, **112**: 350–64. From Bulletin of Hygiene, **6**: 7, 573, July, 1931. Using river water, organisms of typhoid and cholera could not be demonstrated after four to six days, even with initial concentration of 5 million per cubic centimeter. In case of tap water, time was fourteen days and, when water was sterilized before inoculation, organisms died off at slightly slower rate. Tests were made with these two organisms and the flagellate *Bodo saltans*. In this combination, typhoid and cholera organisms disappeared more rapidly. However, this quicker rate of death was not shown in case of typhoid organisms suspended in tap water with the flagellate. Counts showed that the flagellate increased in numbers to a maximum after about 24 hours and then gradually disappeared. This work suggests importance of protozoa as agencies which destroy certain polluting bacteria.—*Arthur P. Miller.*

A System for the Bacteriological Examination of Water. A. J. SALLE. J. Bacteriology, 1930, **20**: 381–406. From Bulletin of Hygiene, **6**: 7, 582, July, 1931. Two media, one for presumptive tests for *B. coli*, the other a differential one for confirmatory tests, are described. Their specific make-ups are stated.—*Arthur P. Miller.*

An Investigation of the River Lark and the Effect of Beet Sugar Pollution. R. W. BUTCHER, F. T. PENTELOW and J. W. WOODLEY. Ministry of Agriculture and Fisheries. Fisheries Investigations, Ser. I, **3**: No. 3, 1930–1931. London. From Bulletin of Hygiene, **6**: 8, 632, August, 1931. In 1926–29, stream pollution work on River Lark in East Anglia in connection with beet sugar factory wastes included detailed surveys from chemical, zoölogical, and botanical aspects. Great numbers of chemical analyses were made, special attention being given to degree of oxygenation. Changes in type of flora under different conditions were studied and micro-flora enumerated. Sugar beet waste was found seriously to deoxygenate the water, causing deaths of numerous fish before they could migrate. Other effects noticed were shortening, or prevention, of autumnal period of diatom growth, production of heavy growth of sewage-fungus, deposition of silt, destruction of normal fauna of stony stretches, and replacement of latter by muddy bottoms.—*Arthur P. Miller.*

Further Experience of the Bismuth Sulphite Media in the Isolation of Bacillus typhosus and B paratyphosus B from Faeces, Sewage, and Water. W. J. WILSON and E. M. BLAIR. J. Hygiene, 1931, **31**: 138–61. From Bulletin of Hygiene, **6**: 8, 649–50, August, 1931. Selective medium employed for isolation of *B. typhosum* and *B. paratyphosum B*, consists of 3 percent agar with addition of glucose, sodium sulphite, bismuth solution, sodium phosphate, and ferrous sulphate. Bismuth sulphite in presence of excess of sodium sulphite is

inhibitory and renders medium selective. Indicator action depends on ability of *B. typhosum* to reduce sulphite to sulphide in presence of glucose. Results of extended use of this medium in examination of Belfast sewage have shown *B. typhosum* to be almost constantly present over period of about three years. One cc. of sewage has, as a rule, contained at least one typhoid bacillus.—*Arthur P. Miller*.

Poisoning by Arsenic. J. K. MACKENZIE. Med. Jour. Australia, 1931, 1: 317. From Bulletin of Hygiene, 6: 8, 657, August, 1931. Occupants of two houses whose roofs had been painted with "pyrites" were poisoned with arsenic. It was found upon examination that paint contained relatively large amount of arsenic and that water from the domestic tank, sole source of supply, contained $\frac{1}{80}$ grain per gallon [0.18 p.p.m.]. [It is presumed that drinking water was collected from roofs and held in cistern.—ABSTR.]—*Arthur P. Miller*.

"Out with Sulphuretted Hydrogen in Drinking Water," says Beverly Hills. ARTHUR TAYLOR. The American City, 45: 3, 77–79, September, 1931. Average per capita consumption of drinking water in southern California is 125 gallons per day, but Beverly Hills uses nearly twice that. First source of water for this city was group of wells in one of foothill canyons. Increased demand led to installation of wells in large valley at lower end of city, water from which was highly sulphuretted, content of hydrogen sulphide running as high as 16 p.p.m., besides considerable iron; while crenothrix and beggiatoa naturally flourished. In 1926, experimental filtration plant was built and proved valuable aid in determining conditions most favorable for purification and softening. Non-sulphuretted water enters aërating room over a 60-foot weir, thins out to over 5,000 square feet, and in this condition receives sulphuretted water, discharged through 70 spray nozzles. Sulphur content is reduced in aëration and mixing processes to about 1½ p.p.m. Primary mixing chambers are next in line, agitation being created by LANGELIER type paddles. From these, water enters Dorr clarifier and passes then to secondary mixing chambers identically similar with first. It then passes through south sedimentation chamber and on to filters. Entire plant is architecturally designed so as to dissemble its commercial, or utility, purpose.—*Arthur P. Miller*.

A Pumping Station Pays for Itself. ELLIS IRVING CRONK. The American City, 45: 3, 105–6, September, 1931. At New Brunswick, New Jersey, installation of new electrical pumping equipment to supersede older steam equipment will, it is claimed, effect over three-year period savings in excess of total cost of the improvement. Dual power lines serve one 8-inch and two 12-inch centrifugal pumps, of which latter, one is also coupled to gasoline engine. Pumps are operated by remote control.—*Arthur P. Miller*.

NEW BOOKS

The Waters of Egypt. A. AZADIAN. Department of Public Hygiene. Notes and Reports of the Labortories of Public Hygiene. Vol. 1: No. 7.

From Bulletin of Hygiene, 6: 8, 661, August, 1931. This publication, in three volumes, describes chemical composition of waters of Nile, including methods for their purification, springs of Nile Valley, waters of Sinai Peninsula, and those of oases of Libyan desert, indicating their location. Third volume consists of geographical charts pointing out sources of supply, methods of installation of works, and some 2000, or more, analyses.—*Arthur P. Miller*.

Papers Presented at the Third Annual Conference of Virginia Water and Sewage Works Association, Lynchburg, Va., November 16–17, 1931. Virginia's Chemical Industry of Today. LAUREN B. HITCHCOCK. Water resources have contributed to phenomenal development. **Open Services Reservoirs.** HOWARD A. JOHNSON. Two open distribution reservoirs of combined capacity of 8½ million gallons, serving Danville, Va., are described. Considerable secondary bacterial growth occurred in 1930, due in north side plant, to (1) 10:1 ratio of capacity to consumption, (2) remote location, 5½ miles from plant, and (3) inlet and outlet being on same side of reservoir. Chloride of lime, and H.T.H. treatment of reservoirs, alike eliminated after-growths. Application was made by dragging burlap bags containing the chemicals across reservoir in 10-foot lanes and cross-checking. Ammonia-chlorine treatment on experimental plant scale was equally satisfactory. During experiment, residual chlorine in distribution system varied from 0.3 to 0.05 p.p.m., declining afterwards to zero. Tadpoles were eliminated from one reservoir by erecting "frog-fence." Dust contamination from near-by drive was eliminated by tarring. Future plans provide for covering reservoirs and for continuation of ammonia-chlorine treatment to eliminate secondary pollution. **Some Notes on Electrically Driven Centrifugal Pumps.** HOMER E. BECKWITH. Centrifugals are designed to operate under fixed conditions, any appreciable change from which will result in decreased efficiency. Factors adversely affecting performance may be (1) greater head, or less, than that designed for; (2) discharge, or suction, partly closed to control flow; (3) failure to allow for friction head. Table and instructions are given for calculating over-all pump efficiency. Check-up may indicate (1) pump obselete; (2) impeller needing renewal; (3) impeller loose on shaft; (4) defective gaskets; (5) fouling of parts with materials; (6) meter set too high; or other defect. Procedure is given for measuring discharge from electrically driven centrifugals. **Metering.** E. H. RUEHL. Chief advantages are (1) fairness, since consumers pay according to consumption; (2) system losses and leakage more readily determined and waste reduced; (3) leaks in consumers' service lines more easily located; (4) essential in establishing equitable water rates; (5) waste by consumer is reduced, resulting in lowered operating cost, and leading to economies incidental to reduced volume of sewage. Objections to metering are (1) that many consumers will either have to pay more, or else to use less water; (2) possible impairment of sanitary conditions, due to curtailed consumption. Author holds that under conditions prevailing in western Virginia, meters should be owned by water department, or company, and charged to capital. Meters should be set in sidewalk space behind the curb line, because (1) it greatly facilitates meter reading; (2) line of separation between water department's and property owner's liability is clearly defined; (3) cut-offs are more easily made; (3) dan-

ger from tampering, or from changes in temperature, is less. Concerning small meters, up to one-inch, in western Virginia, it is well to set them in a yoke with at least a control valve on inlet side, doing away with curb-stop and box. Meter, yoke, and valve should be set in earthenware, concrete, or iron box, with sufficient clearance between risers, if used, to prevent freezing. A satisfactory type of box is one 18 inches in diameter by 24 inches deep, with slots for varying depth of service pipes. There should be a tight fitting cover with locking device. Meters should be read at least monthly, to reduce possible leakage and to correct stopped meters. With services fairly close together, careful preliminary planning, and systematic field work, it is estimated that one foreman with six meter-setting gangs and hole-diggers can set approximately 150 meters per week. **Measures Used for Removal of Tastes and Odors in Filtered Water at Newport News, Va.** E. F. Dugger. Supply is derived from shallow impounded lakes which favor rapid growth of algae. Latter produce objectionable tastes and odors. Heavy precipitation following 1930 drought effected color increase with pronounced taste and odor, resulting in many complaints from consumers. Activated carbon (Nuchar No. 2) applied at rate of 0.1 grain per gallon overcame the trouble. Five pounds of carbon were agitated with water in Coca Cola barrel by means of paddles actuated by electric hand drill. Mixture was fed into influent at point 25 feet from first filter with ⅜-inch hose extending 10 inches into flume. Barrel was controlled to empty in about one hour. Cost of this treatment was approximately 75 cents per m.g. Within 8 hours from beginning treatment, filter effluent was free from all taste and odor without runs being shortened, or carbon detected in the finished water. **Measures Used for Removal of Tastes and Odors in Filtered Water at Norfolk, Va.** R. W. Fitzgerald. Within past few years, taste and odor problems have become urgent, due to increased stream pollution, including trade wastes, to more exacting standards of quality in mind of consumer, and to extreme drought conditions. Problem in Norfolk became acute with opening of Lake Prince in 1926. Stored since 1920, water was high in organic matter and had a woody taste quite resistant to treatment. Sludge in settling basins was highly putrescible and required careful handling to prevent bad tastes from becoming intensified. Furthermore, prolific seasonal growth of algae in Lake Prince contributed musty, earthy, and fishy tastes. Prechlorination was only partly successful. Withdrawal of bottom water from the lake was helpful during the spring and fall "turn-over." In spring of 1930, prechlorination and ammonia-chlorine treatment were only partially successful. In February 1931 conditions were much worse, necessitating prechlorination at rate of 2.5 p.p.m. and copper sulphate treatment of the lake. Plant treatment with slightly less than 0.1 grain per gallon of activated carbon in June, was followed almost immediately by practically tasteless effluents and cessation of consumers' complaints. Approximate cost was 70 cents per m.g. **Report of Operation of Blacksburg Sewage Treatment Plant.** F. J. Settle. **The Hollins Sewage Treatment Plant.** W. M. Johnson. **Experiences in Starting A New Sewage Disposal Plant.** S. L. Williamson.—*R. E. Noble.*

Examination of Water. William P. Mason and Arthur M. Buswell. Sixth Edition, 1931. John Wiley and Sons, Inc., New York City, 224 pages.

Price, $3.00. Possibly there is no book on water analyses that has been so widely distributed as this work, which for many years has been considered a standard text on the subject. The authors have retained the same clarity and simplicity in the presentation of the scientific facts as in the earlier editions, an essential feature in a book of this kind. Portions of the original text are now obsolete, but have been included in the present revision. There may be a tendency to criticise this practice, but considered from a historical viewpoint, these data are invaluable and logically should be retained. They furnish the reader specific information on the development of the art, not readily procurable elsewhere. As in the original edition, the book has been divided into two sections, the first four chapters covering physical and chemical tests and one chapter is devoted to the bacteriological analyses of water. A number of additional tests have been included and there is much new material on water analyses and water purification practice. Chapter four covering instructions and methods of calculation for the control of water purification, coagulation and chlorination should prove invaluable to student chemists and engineers who have no special training on the subject. Detailed instructions have been included for boiler water analyses, and procedure for the colorimetric determination for manganese, silica and phosphates. This portion of the text should appeal to industrial chemists, thus opening a new field for the book which was not available during the periods of the earlier editions.

An elaborate appendix has been included. Some of this material appears to be misplaced, since it should have logically been included in the body of the book. This is particularly the case in respect to the instructions for the preparation of permanent standards. There appears also in the appendix the Report of the Advisory Committee on Official Water Standards, including the complete mathematical discussion of the procedure for determining the *B. coli* index of water. Probably the most valuable addition to the present edition is the portion of the text relating to boiler water analyses and the discussion of the determination of hydrogen ion concentration of water.—*Sheppard T. Powell.*

Report of the Working of the Water Analysis Laboratory, Corporation of Madras, for the Year 1930. S. V. Ganapati. 8 pp. 1931. During 1930, prechlorination (1.25 to 1.5 p.p.m.) and slow sand filtration at rate of 6 inches vertical per hour [3.9 m.g.a.d.] continued to be employed for purification of water supply of Madras, derived from Red Hills Lake. As in previous years, production of hydrogen sulfide in filters during hot weather led to formation of whitish trailing filaments on weirs and on sides of filtered water chambers, collecting conduit, and reservoirs. These gelatinous growths were identified as *Beggiatoa* and *Thiothrix*. Filtered water at times contained as much as 5 p.p.m. of hydrogen sulfide. Numerous complaints were received regarding odor of water and growths present in distribution system. Filters did not function as efficiently as during previous year and water delivered was of poorer bacteriological quality. Atypical vibrios were occasionally detected in the raw water. Sporadic cases of cholera were reported in July and August, most of which were traced to neighboring villages. Average daily consumption was 18.84 million Imp. gallons. Plans are being prepared for installation of per-

colating filters which will operate at rate of 24 inches vertical per hour [15.5 m.g.a.d.]. When these are constructed, sand filters will be operated as secondary filters at rate of 8 inches vertical per hour [5.2 m.g.a.d.]. Results of chemical and bacteriological examinations made during year are tabulated.—*R. E. Thompson.*

Proceedings of Lake Michigan Sanitation Congress at Hammond, Indiana, June 27-28, 1924. 90 pages. **Resolutions.** 5-7. The more important resolutions are as follow. That pollution of Lake Michigan with raw sewage is a dangerous make-shift and growing menace to life and health of all Lake Michigan municipalities. That all of latter so polluting be urged to eliminate practice and proceed with utmost diligence to install and operate water filtration and sewage treatment plants at earliest date possible. That, pending latter, it is agreeable that Sanitary District of Chicago divert sufficient water from Lake Michigan to safeguard life and health. That federal, state and municipal regulations as to dumping dredged material in Lake Michigan be compiled and investigated by the Congress. That, since the condition of southern end of Lake Michigan from 68th St. Chicago to Gary, Ind., and of Calumet Rivers warrants investigation of pollution extent, its sources, causes, and affectation of water supply of nearly one million people; since the directors of Illinois and Indiana State Boards of Health, Chicago Commissioner of Health, and Chicago Sanitary District Board of Trustees have petitioned Surgeon General of United States Public Health Service for investigation of sanitary conditions in the Calumet region as coöperative survey; and since the Congress is considering ways and means of securing pure water for communities represented; the Congress endorses the investigation, urges coöperation between interested bodies, and also urges the Surgeon General to assist. That each state form a local section of the Congress. That, since Indiana has time-limited discharge of raw sewage into any lake, Illinois, Michigan, and Wisconsin are urged to do the same. That Illinois, Indiana, Wisconsin, and Michigan be requested to designate representatives to serve on Advisory Board of the Congress. **Correlation of Sewage Treatment With Water Purification in Lake Michigan Cities.** C. M. BAKER. 9-11. Statistics on 28 Wisconsin cities aggregating 810,306 population emphasize necessity of properly controlling sanitary conditions if public supplies and health of citizens therein are to be properly conserved. Seventeen cities are located directly on shores of Lake Michigan. Greatest danger of lake pollution is in its effect upon public water supplies. It is impracticable to control pollution so as to maintain lake water satisfactory for public consumption without treatment. **Lake Pollution at Milwaukee.** RUSSELL CUNLIFFE. 12-13. Descriptive and historical sanitary data are given re the Lake Michigan supply from 1912 to 1921. **Sewage Pollution of Lake Michigan.** W. A. EVANS. 14-23. There is no regularity of current due to tributary, or discharge, streams, or to wind action, in Lake Michigan. Geographical conditions necessitate use of lake water by shore cities. Consequently, unusual and extraordinary protective measures against sewage pollution are necessary. Earlier insanitary conditions, accounting for a high death rate for water-borne diseases, are described. Distinction is drawn between diversion of pollution from Chicago via the Sanitary Canal and dilution of the

sewage to assure inoffensiveness and discomfort to cities down stream. The drop in death rate coincident with sewage diversion is cited. In 1908, typhoid conditions in the cities of E. Chicago, Indiana Harbor, Whiting, and Hammond were as bad as those in Chicago in 1891 when typhoid death rate was 175. Present reduced rate should not be boasted of until brought to Chicago level. Author predicts necessity for some greater protection than merely filtration and chlorination. Coöperation between cities is urged. In his opinion, safe, pure water supply is of paramount importance and consideration. **Remediable Causes of Water Pollution.** Isaac D. Rawlings. 24–31. Causes of water pollution are domestic sewage and industrial waste. They may be remedied and removed by (1) a still further awakening on part of municipal officials and citizens, and of industrial managements to their duties and responsibilities relative to water pollution; (2) obtaining legal means of financing construction and operation of treatment works where such legal means may not now exist; (3) application of present knowledge and principles of treatment of sewages and wastes, where such knowledge is adequate, e.g. in case of domestic sewage, and experimental and research work where knowledge is incomplete, e.g. in case of certain industrial wastes; (4) clarification and expansion of some State laws and better consolidation of such work in State health departments with provision for more adequate personnel and funds; (5) better enforcement of existing laws where same are now being violated; and (6) more freedom from politics of an objectionable character, so that those designated to enforce the laws can reach opinions and take action upon results of scientific studies and upon actual facts. **Indiana Sources of Lake Michigan Water Pollution.** L. A. Geupel. 32–38. It is opinion of Water and Sewage Department of the Indiana State Board of Health that for all water supplies, whether taken from individual intakes extending far out into Lake Michigan, or from one intake serving several communities, modern filtration methods and sterilization must be placed in efficient use by Indiana cities in the near future. It is also conceded that modern sewage disposal plants must be installed and efficiently operated; that all sewage and industrial wastes should be eliminated from direct discharge into Lake Michigan; and that purification of industrial wastes should be adopted wherever modern engineering practice can give methods of practical efficient treatment. It should be the earnest desire of all cities located on Lake Michigan that pollution of lake be held to a minimum so that healthy conditions may exist in all cities bordering thereon. **Indiana's Crusade for Pure Water.** Wm. F. King. 39–41. In 1905, Indiana began campaign to improve quality of state water supplies and educate the public on importance of sanitary sewage disposal as a prime factor in safeguarding water supplies. In early times, springs and artesian wells were in abundance. But water table has been receeding, so that wells and small impounded supplies will become inadequate, making it necessary for inland communities to depend on Lake Michigan as source of supply. State Board of Health has endeavored to be of assistance in preserving the purity of state water supplies through laboratory service and expert sanitary engineering counsel. This service is increasing. In 1924, Board prohibited use of cross-connections with secondary supplies. In 1926, it prohibited discharge of raw, or insufficiently treated, sewage into any Indiana lakes. **The Relation of the Federal Government to the**

Control of Stream Pollution. W. H. Frost. 42–43. Federal Government has legitimate interest in condition of streams and in quality of public water supplies throughout the country. So far Congress, although authorized, has not seen fit to control stream pollution not affecting navigation. At present each state is responsible for control within its boundaries. While statutes differ in various states, there is a tendency toward uniformity of policies. Stream pollution control is usually vested in state health department. The United States Public Health Service has served to bring state health authorities together for discussion of problems and policies. The part played in control of stream pollution, however, has been chiefly that of an investigating agency, studying general and local problems, with view to developing methods and principles of procedure to be applied by the states. The P.H.S. exercises some administrative control in examination of water supplies furnished passengers on inter-state carriers. It can only forbid use of such supplies by such carriers when found contaminated. **A Review of the Water Supply and Sewage Conditions of the Towns Around Lake Michigan and the Remedies Therefor.** Langdon Pearse. 44–51; with map of Sanitary District and Dilution Project. In protection of water supplies around Lake Michigan, it is essential to ascertain first relation of sewage discharged to water intake, and then, other sources of pollution. With this information, desirability of water filtration and need to remove sewage outfall further away from intake can be investigated. In general, first step is to protect the water supply, chlorination being an easy temporary method, to be reinforced with filter plant, particularly if turbidity is found. Sewage treatment should then be considered and its effect, not only on water supply, but on bathing beaches. Degree of treatment required will depend upon local conditions. Even when water supply is filtered and other precautions taken, situation demands continued watchfulness, with analytical control of all operations, since failure of defences set up will mean sickness and death for the community. Constant efficient control is required, with skilled operators under technical guidance. In this, representatives of State Board of Health can aid by occasional inspections and constructive criticism. **Measures Adopted by Milwaukee to Prevent Pollution of Lake Michigan.** William R. Copeland. 52–55; with two photo-diagrams. Sewage from 500,000 people and wastes from great variety of industrial plants in Metropolitan area enter Lake Michigan at Milwaukee Bay. Immense numbers of pathogenic bacteria pollute water supply of city and its neighbors; organic matter uses up oxygen of lake water; and quantities of mineral matter are deposited in river channels and in bay. In order to cope with these conditions, State Legislature authorized formation of Metropolitan Sewerage Commission. Latter was faced with problems of sewer construction and of waste disposal. Preliminary studies determined the adoption of activated sludge system of disposal. Technical aspects of latter, with description and advantages of proposed system are given. **Cleaning Michigan Streams.** Ernest F. Badger. 56–59. Pollution of Lake Michigan by Michigan cities is not at present great. Type and treatment of water supplies of fifteen cities are given, with nature of local problems.

Several other cities and industrial concerns are undertaking sanitary measures which will correct pollutional conditions on eight rivers and one lake, serving as water supplies. At best, considerable time will be required. Pollution

of Flint River by City of Flint and resultant litigation are described. Michigan statutes do not provide for creation of Sanitary, or Metropolitan, Districts which would help to reduce stream pollution by domestic and industrial wastes. Latter type offer greater problem, owing to their putrescible nature. **Chicago's Right to Divert Water From Lake Michigan.** ROBERT ISHAM RANDOLPH. 60–67; with Map of Sewage Treatment Projects and Table of Future Construction Schedule. Health and welfare of more than three million citizens of Chicago are jeopardized by action of certain persons and interests who are seeking to restrict right of people of the city to divert water from Lake Michigan in volume sufficient to provide adequately for sanitary necessities. The equities demand that Chicago shall not be permitted to solve her own domestic problems at expense of other cities and interests on the Great Lakes, but it is not proved that the Chicago diversion has injured any other city, or interest. Remedy for any lowering of lake levels is restoration of former depths. In their essentials, plans are for constructing remedial works, compensating works, or regulating dams, in the interlake channels. Sanitary District of Chicago, seeking to compromise the controversy, has by ordinance, resolution, and tender of funds to the Secretary of War, offered to pay the cost of construction of such works to be built on designs and under direction of the United States Government Engineers coöperating with engineers of Dominion of Canada, and now seeks necessary legislation in Congress of the U. S. to validate such a treaty agreement and to authorize construction of these works. Chicago is transgressing no law, infringing no treaty, is injuring nobody, and is entitled to a square deal. **Bacteriological Study of Lake Michigan Water, Raw and Treated, from Waukegan to Gary.** F. W. MOHLMAN and C. C. RUCHHOFT. 68–90. From December, 1923, to October 1, 1924, Sanitary District of Chicago made bacteriological survey of Lake Michigan from Waukegan, Ill., to Gary, Ind. In 10,600 samples examined were included those from Chicago lake front and from various pumping stations. Laboratory tests made are outlined. Gelatin counts, agar counts, and *B. coli* determinations made on raw and tap waters from Chicago and suburban sampling points are discussed briefly. Discussing filtration plus chlorination *versus* chlorination alone, authors point out value of filter plant toward assuring safety of water supply. Chlorination alone of highly polluted water is neither satisfactory, nor safe. Even with filtration plus chlorination, there is a limit of pollution above which there is cause for concern. There is little doubt but that this limit has been exceeded in the Calumet District and that the filter plants are overloaded by excessive pollution of the raw water. Remedy for this condition lies in sewage treatment and substantial reduction of bacterial content of raw water. Ten tables present the survey data. **Appendix** includes summaries of Water Treatment and Sewage Disposal Data for Illinois, Indiana, and Michigan.— *R. E. Noble.*

Bibliography of Bibliographies on Chemistry and Chemical Technology. The National Research Council announces the publication of Bulletin 86, which is the Second Supplement to the Bibliography of Bibliographies on Chemistry and Chemical Technology covering the period 1929–1931. The original Bulletin (No. 50) covered the period 1900–1924 and contained about 10,000 bibliographies classified under 2400 headings. The First Supplement (No. 71) cov-

ered the period 1924–1928 and contained about 4000 bibliographies under 1050 headings. The Second Supplement (No. 86) covers the period 1929–1931 and contains approximately 3300 bibliographies under 950 headings. As the title indicates, the work (as in the case of Bulletins No. 50 and 71) is a compilation of bibliographies published as separates, or at the end of books or magazine articles, or as footnotes to the same, on the numerous aspects of pure and applied chemistry. Each entry gives name of author or compiler, title, and place of publication. The majority of the entries state the number of references, thus giving an indication of the completeness of the particular bibliography. The entries are classified under the proper subject-headings, alphabetically arranged. The duplication of individual entries has been largely avoided by the liberal use of cross references. As an example of the value of this compilation, the following information is given regarding the number of bibliographies reported in Bulletin No. 86 for some of the more important topics: Biochemistry 32, Blood chemistry 75, Carbohydrates 29, Ceramics 18, Coal 16, Colloids 30, Cement and Concrete 35, Fats 33, Fertilizers 34, Foods and Feedingstuff 49, Hormones 31, Iron and Steel 90, Metabolism 72, Milk 44, Paper 35, Petroleum 65, Plant chemistry 39, Rubber 35, Soils 76, Vitamins 41, Water 33. These Bulletins may be obtained from the Publication Office, National Research Council, Washington, D. C., at the following prices: No. 50, $2.50; No. 71, $1.50; No. 86, $1.50. *Special price* on complete set ordered at one time (no discount to dealers), $4.00.

Erratum. In March 1932 issue, p. 456, line 9, for "and treated with ammonia" read "which has at times been advantageously supplemented by treatment with ammonia."